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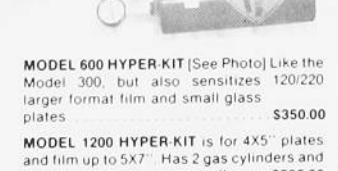

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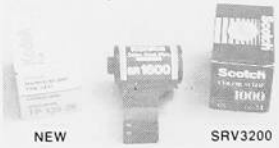

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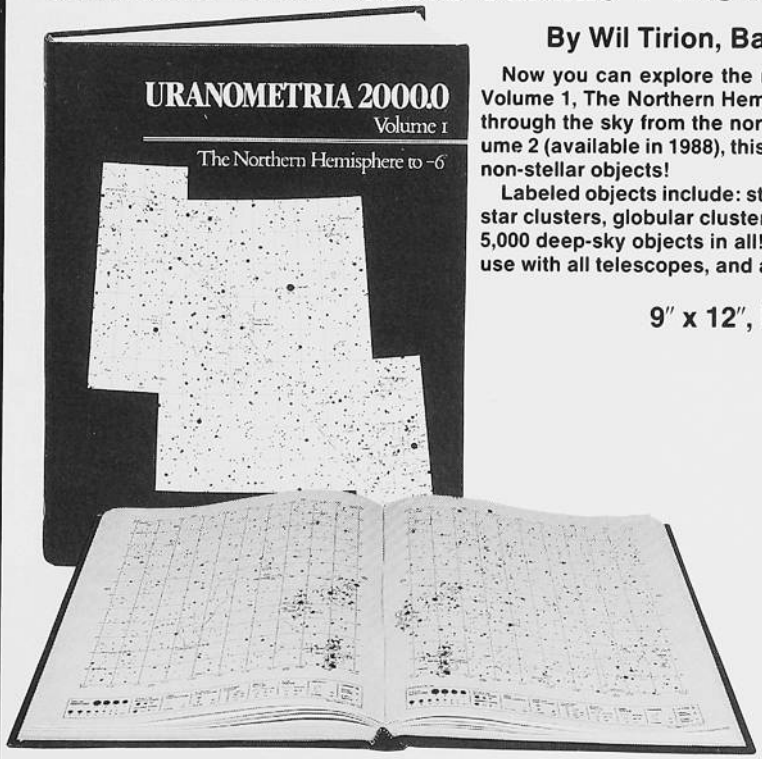
URANOMETRIA 2000.0 Volume 1 The Northern Hemisphere to -6°

By Wil Tirion, Barry Rappaport, and George Lovi



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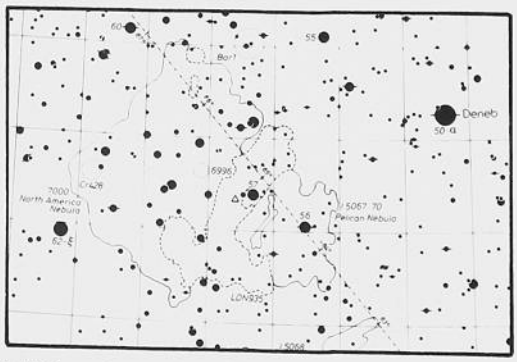

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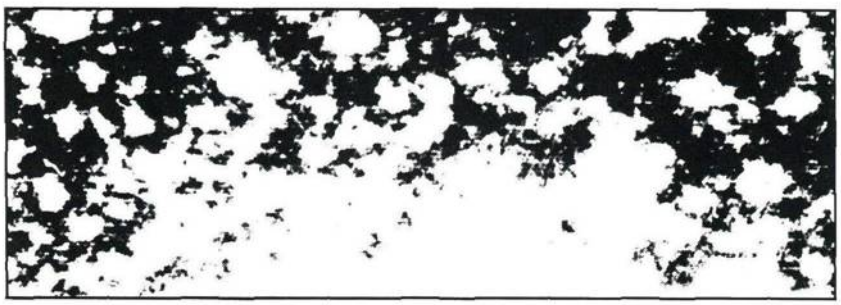
The Galaxies of Canes Venatici
by Max Radloff

8 *Some ninety bright galaxies lie in the tiny constellation Canes Venatici, including familiar objects like the Whirlpool Galaxy and M63. However, as Max Radloff's article shows, some of the most interesting galaxies in Canes Venatici are lesser known.*



Pushing to the Limit: The Palomar Clusters from Your Backyard
by David Higgins

16 *Fifteen distant globular clusters discovered at Palomar Observatory are among the faintest and most obscure globular clusters known. David Higgins reports that at least five of these clusters are visible in large-aperture backyard telescopes.*

Observing the Centaurus Galaxy Cluster
by Jeffrey Corder

22 *Centaurus is best known for Omega Centauri and the bright lenticular galaxy NGC 5128, but as Jeff Corder tells us, a marvelous galaxy cluster in Centaurus is also within the range of backyard instruments.*

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AND ASTROPHOTOGRAPHERS

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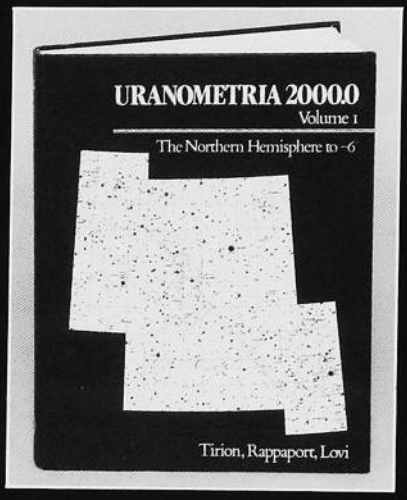
ON THE COVER: The peculiar eruptive galaxy M82 photographed by Kim Zussman, who used an 11-inch f/10 SCT, hypersensitized Tech Pan film, and a 50-minute exposure.

Inside View

Uranometria Reconsidered



The publication of the first volume of *Uranometria 2000.0* caused a great sensation in the world of amateur astronomy. The atlas was hailed by one of the authors as being "as significant for our day as Bayer's star atlas [*Uranometria*] was for his day." The authors promised a significant leap forward for amateur observers by including 332,556 stars down to magnitude 9.5 (in both volumes) and many thousands of deep-sky objects not present on Tirion's *Sky Atlas 2000.0*. Indeed, *Uranometria 2000.0* is a great leap forward for the average backyard observer. But it isn't perfect.

Because of the high visibility of this product, debate has raged about the merits of *Uranometria 2000.0* among circles of backyard sky observers. Is it as wonderful as it claims to be? Is it the last star atlas I'll ever have to buy? Or are there flaws hidden somewhere in this atlas unknown to me? Opinion about *Uranometria 2000.0* seems to take one of two paths: people either unequivocally love it, or they have misgivings about its shortcomings. These contrary points of view were each eloquently stated in two reviews of *Uranometria 2000.0* published in the February 1988 ASTRONOMY.

Brian Skiff, an astronomer at Lowell Observatory in Arizona, is an expert on stellar and deep-sky databases and celestial cartography. His review dripped with disappointment as he described how the star positions used in the atlas were for epoch 1855.0 and how the authors would have had a hard time correcting all of the proper motions of stars over the last century and a quarter. He also expressed regret that the authors chose secondary source catalogues for variable stars, double stars, and deep-sky objects. This led to some doubles and variables being plotted but unmarked on the charts. It also led to the authors repeating mistakes made in the *RNGC*. The atlas includes only a handful of dark nebulae and it excludes many of the *Index Catalogue* objects. These are pretty severe problems for a serious deep-sky observer.

Nevertheless, Skiff concludes by stating that "*Uranometria 2000.0* is undoubtedly a boon to the average deep-sky observer." A review by Dick Suiter that follows unabashedly drools over the new atlas, unaware that it contains any serious flaws. Suiter ends by stating: "This is an atlas that will stand as a high watermark [sic] for many years to come. It is a work so huge that it is daunting to anyone who would attempt to surpass it." How could both of these reviews be correct?

The answer comes down to whom this atlas is really aimed toward. If it is intended to be the star atlas to end all star atlases, a serious reference for the serious and knowledgeable observer, it has failed to be "as significant in our day as Bayer's star atlas was for his day." However, if it is intended as an extension of *Sky Atlas 2000.0* for a general observing auidence, it is a delightful book. There you have it. Enjoy this magnificent new work with the knowledge that it isn't perfect, but don't be afraid to use it.

Dave Eicher
Editor-in-Chief

Letters to DSM

Mystery Objects

Dear Dave / Might I offer the following designations and descriptions in response to Gregg Thompson's "Mystery Emission Nebula and Globular Cluster" in the Fall issue:

1. Cederblad 122 in Centaurus is a rather large region of nebulosity visible to the unaided eye as a patch of light slightly brighter than the surrounding Milky Way. It encircles the 4th-magnitude star m Centauri. It is well shown by sweeping my 10x50 binoculars slowly across the field and is an easy object in 20x80 binoculars. The nebula is irregular, almost round, and 2.5° in diameter with the brightest area northeast of m Centauri.

South of m Centauri and across the boundary into neighboring Musca is the nebula Cederblad 123. Excitation of this area of nebulosity appears to originate with the nearby early-type star Theta (θ) Muscae of spectral class O.

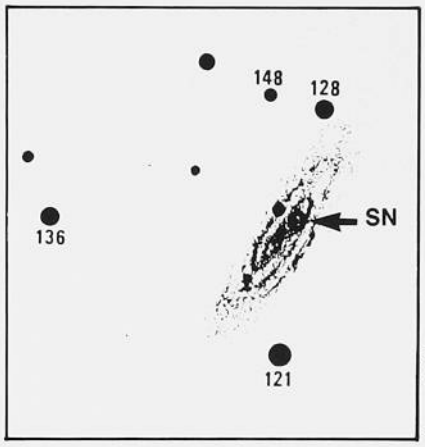
2. NGC 121 is a globular cluster associated with the Small Magellanic Cloud and located only 30′ north of the delightful cluster NGC 104, or 47 Tucanae. A low-power eyepiece shows both objects within the same field.

My 6-inch f/8 Newtonian shows NGC 121 as a small and faint nebula, unresolved, though obvious with direct vision. It is clearly oval in character, some 2.5′ by 1.5′ in extent, and of fairly even light with a broad, slightly brighter center. A 12th-magnitude field star lies adjacent to the cluster's southwestern edge.

On another matter, Thompson's "An Identity Crisis for IC 2948?" (Fall letters) raised some interesting questions. What is commonly regarded as IC 2948, an open star cluster, was visible with my 6-inch f/8 scope back on February 8, 1983. I observed the cluster at 50x and 140x and described it as follows: "An easily located cluster only 25′ southwest of the brilliant white star Lambda Centauri. This is a large cluster of both bright and faint stars surrounded by a rich field into which the outliers merge. The total extent is 20′ by 10′, elongated northeast-southwest, with a marked concentration measuring some 5′ by 3′ at the northern end and lying between two single white stars of magnitude 7; stars are of magnitudes 7 to 12 and number about fifteen.

"Located at the southwestern end of the cluster is a coarse pair of estimated magnitudes 8 and 9 in p.a. 280°. About twenty faint stars are visible between this pair and the brighter concentration to the north."

The identity crisis apparently lies with the true nature of IC 2948. This designation refers to an extensive HII region, as observed by Thompson, which was discovered photographically by Frost (=F790) as part of a Harvard College Observatory search for emission nebulae. It is included in the second *Index Catalogue* with the vague but appropriate description "eeL". The associated cluster of young stars was apparently overlooked (overexposed?) and therefore not mentioned.



Gregg D. Thompson

Finder chart for the supernova in NGC 7606 with north up and east to the left.

The cluster associated with IC 2948 appears within the pages of Shapley's *Star Clusters* (1930) and Alter's *Catalogue of Star Clusters and Associations* (1958), both of which were used by Becvar in his *Atlas Coeli Catalogue* (1964). Thus IC 2948 was introduced to the masses as a star cluster. This error was passed on through the pages of *Burnham's Celestial Handbook* and *Sky Atlas 2000.0*.

More recently James D. Wray included IC 2948 as an HII region with associated star cluster in his *Study of H Emission Objects in the Southern Milky Way* (1966), as did van den Bergh and Hagen in their *Uniform Survey of Clusters in the Southern Milky Way* (1975). Alternate designations from the *Master List of Nonstellar Optical Astronomical Objects* (*MOL*) are HN790 (=F790), WRAY 19.37, VHA122, and OCL864.

However, a further identity crisis may involve the star cluster OCL862, listed as IC 2944 and Collinder 249 in *Sky Catalogue 2000.0*, at very nearly the same position of Lambda Centauri and at a location where I have not been able to identify any cluster. Perhaps this is another misidentification of the IC 2948 association? Also, IC 2944 (=F789) was originally listed as a large nebula surrounding Lambda Centauri, not as a star cluster.

This most interesting region is also listed in the *MOL* as the Centaurus OB 2 Association, ASS62, and LYNG 07.

Peter F. Williams
3 McAuley Close
Heathcote, 2233
New South Wales, Australia

Dear Dave / The "mystery" emission nebula has created considerable intrigue for many Australian observers and some from the United States and Canada, who have forwarded guesses. Before divulging its identity, you might be interested to know that because of its basic "S" shape, it is often assumed to be a barred spiral galaxy. It is so bright it can be glimpsed with the naked eye, yet incredibly it lies in another galaxy! With these clues some Southern Hemisphere observers who wrote proposed that it was in the LMC, only to be wrong. It is a massive emission nebula like M8 that lies in the "tail" of the Small Magellanic Cloud. Two bright star clusters and some associated nebulosity lie in the same field.

The nebula is designated NGC 346 and it lies at right ascension 0h59.0m, declination −72°11′ (2000.0). Strangely, Tirion has not plotted this bright object or several other bright objects in the SMC on *Sky Atlas 2000.0*, yet a faint SMC nebula dubbed NGC 602 is plotted on the atlas.

The mystery globular was NGC 121, at right ascension 0h26.7m, declination −71°33′ (2000.0). It is also a member of the SMC. It simply happens to lie along nearly the same line of sight as 47 Tucanae. A third globular, NGC 152, lies on the opposite side of 47 Tucanae, almost among the big cluster's outlying members. NGC 152 is slightly larger, fainter, and less condensed than NGC 121.

I think the Magellanic Clouds are so abundant in deep-sky objects that Southern Hemisphere observers somehow became jaded and now ignore them. This is especially true because there is no suitable, easily available atlas for observing them. For some years now Mati Morel and I have been working on producing an atlas of both galaxies so amateurs may be able to observe the many objects in them.

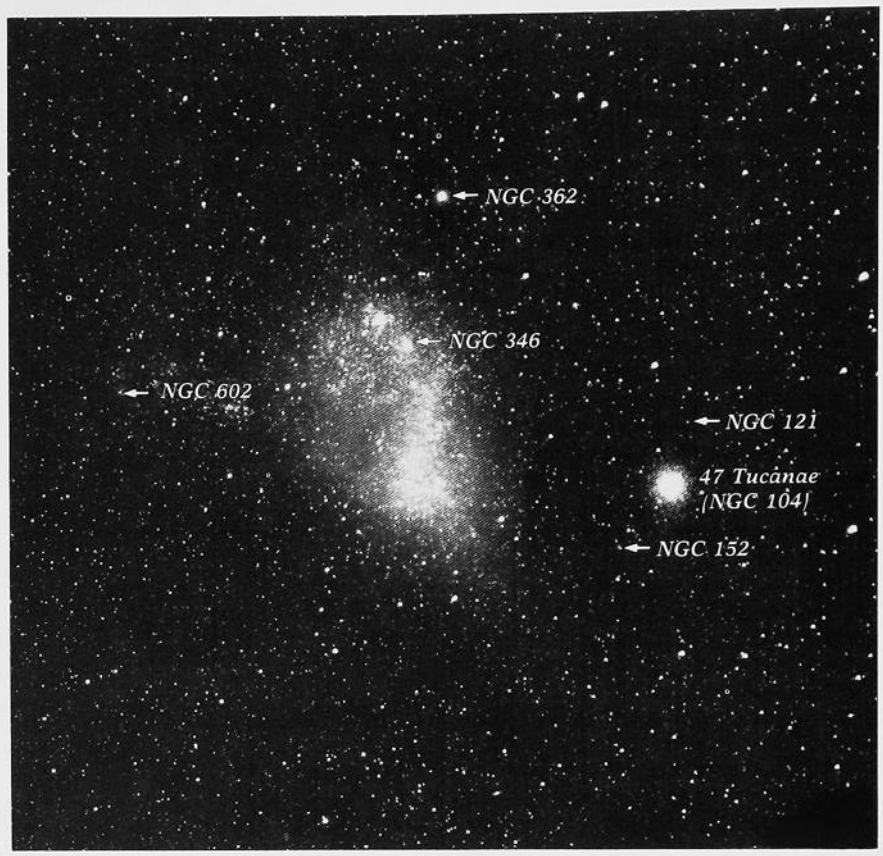
Some *Deep Sky* readers who wrote me about the mystery objects had difficulty eliminating possibilities because no

details were published about the field diameters of the drawings, the field orientations, or the eyepieces used. These details were provided and I believe it is imperative that they be published with all drawings. Apart from the factors mentioned above, I often wonder about other things like the optical quality of the observer's telescope and eyesight are like. How experienced is the observer? What were the conditions at the time of the drawing? As *Deep Sky* regularly contains articles of high standard, is it not time to publish such crucial factors along with drawings?

Many deep-sky observers make methodical, scientific observations of real value, but we must demonstrate this if we seek to earn respect from observers in other disciplines as you discussed in the Fall issue editorial. What would we think if an astrophotographer did not provide the details of his photograph, like film type, exposure, development and printing information, etc.?

Vague, one- or two-line descriptions say little if anything that has not been regurgitated in numerous other articles and books. As observers, can't we standardize our comments to help others appreciate the sketches we make?

I have more information on the second letter of mine you published in the Fall issue. The identity crisis of IC 2948 has prompted some interesting research by readers who have corresponded with me and talked with me at the recent Mount Kaputar Astrocamp in Australia.



Harvard College Observatory

Bright Objects in the Small Magellanic Cloud

When it comes to IC 2948, there appears to be considerable inconsistency from one catalogue to another. IC 2948 appears to refer to both a cluster of seven bright stars and the emission nebula in the region. The cluster is much larger than the symbol on *Sky Atlas 2000.0* makes it appear, and the symbol should include the four stars plotted north of the symbol on that atlas. These cluster members were plotted in my drawing of the cluster, and they are O and B stars.

Sky Catalogue 2000.0 disagrees with the atlas by naming the cluster IC 2944 instead of IC 2948. The cluster is also known as van den Bergh-Hagen 121 and Collinder 249. *Sky Catalogue 2000.0* describes the cluster as a 15'-diameter object that is weakly concentrated, poor in population, and with a small magnitude range. This description is accurate, although Peter Williams of Sydney advises me that the catalogue's position for the cluster is wrong.

To confuse the matter further, *Sky Atlas 2000.0* does not show the emission nebula but does show a much fainter nebula around Lambda Centauri. The nebula was invisible to me when I used a 16-inch scope and to Alister Ling who used a 17.5-inch scope while he was in Australia for Halley. It is also nearly nonexistent on the enclosed photo by Steve Quirk, made with a 10-inch f/5 scope and a 24-minute exposure on hypersensitized VR 400 film.

Steve Quirk

The mysterious nebula and cluster, IC 2944 and IC 2948, photographed with a 10-inch telescope.

Long-exposure photographs reveal the nebula around Lambda and the other around the star cluster both belong to a huge complex of nebulosity known as RCW 62. To make things still more confusing, a catalogue of nebulae in Carina suggests IC 2944 refers to the entire area. This suggests that IC 2948 is the cluster and IC 2944 is the nebulosity. However, Alister Ling advises me that the *Index Catalogue* states that IC 2944 is a small cluster embedded in nebulosity and that IC 2948 is a large nebula. This is also confusing because the positions in the *IC* indicate IC 2948 is the nebula behind Lambda but that object should be the smallest of the two, not the largest as the *IC* states. What a confusing set of descriptions!

I have also enclosed a supernova search chart for the region of NGC 7606, the galaxy in which Reverend Robert Evans discovered his latest supernova. The object was discovered on December 14, 1987, with a 110-inch reflector while Evans was visiting Siding Spring Observatory. The object shone at magnitude 13.8 at discovery and lies 16″ west and 27″ north of the nucleus. Readers may wish to observe this object and estimate its magnitude.

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The Galaxies of Canes Venatici

by Max Radloff

No matter what size your telescope is, many galaxies your telescope will show you will be dim little ovals with brighter middles. If you are getting a little bored with these faint fuzzies and would like to view some galaxies that are both large and bright, the sometimes overlooked constellation of Canes Venatici offers a variety of prominent galaxies with interesting structure, including a number of interacting pairs. Even if you don't own a large-aperture telescope, there is much you can enjoy here, because you can see many details with scopes of 8-10 inches in aperture if you sharpen your observing skills and push your eye and your instrument to the limit.

Layers of Galaxies

Many of the brightest galaxies in the sky belong to the long string of galaxy groups that stretches from the Sculptor group through our Local Group out to the heart of the local supercluster in Virgo. All of the brighter galaxies in western Canes Venatici are in this string, and they are in three distinct layers projected onto the same area of the sky. Closest to us at a distance of 5 megaparsecs (assuming H_0=75) is the CVn I cloud that contains M94 and M106 and NGCs 4214, 4244, 4395, and 4449. Behind this at almost twice the distance are both the CVn II cloud and the M101 group. The former contains NGCs 4111, 4242, 4290, 4618, 4631, and 4800, and the latter has M51 and M93 as outlying members. In the third level at 55 megaparsecs are the various parts of the UMa I cloud including NGCs 4145, 4151, 4217, 4369, and perhaps 5005 and 5033. The rich group in the eastern part of the constellation is much more distant at 30 megaparsecs, roughly twice the distance of the Virgo cluster.

Observing Galaxies

I suspect that my experience as a galaxy observer is like that of most amateurs: I was initially disappointed at seeing a series of faint and featureless objects and not even being able to find many of the galaxies on the charts. After several years of observing, I gradually found myself not only finding all the galaxies in the Tirion atlas but even glimpsing some too faint to be plotted, and galaxies that were formerly structureless now contained faint but definite spiral arms, knots, and dust lanes.

The best advice for someone who has not yet discovered the pleasures of galaxy viewing is simply to do a lot of looking. Don't be in a hurry to see lots of objects, but take plenty of time to look at each one and compare the view at many different magnifications. Let your eye relax and scan the galaxy, looking for subtle variations in the light. If you glimpse something you haven't seen before, keep looking and try to make certain of it. Once you have seen a detail, it will stick in your mind's eye and it will be easier to see the next time you observe.

A multitude of little things can improve your viewing, such as clean optics, a tube designed to eliminate stray light, and enhanced mirror coatings. Find the darkest site you can, even if it means a longer drive than usual, plan to observe when the dew points are low, and keep in mind that your dark adaptation will keep improving even after two or three hours.

Magnification

The last piece of advice may surprise those who have never tried it. Don't be afraid to magnify galaxies! Only the most diffuse objects are best at the lowest power. Almost all will be better seen at 15x per inch of aperture, and even higher power can be used on many.

Increasing the magnification helps in several ways. First, it makes the sky around the galaxy darker, which increases the contrast between the galaxy and the sky. More important, because the eye can not see detail that is both small and faint, magnification enlarges faint detail to the point where the eye can perceive it.

Because there are so many variable factors in observing, it is hard to predict in advance which powers will give the best view, so the best advice is simply to try different magnifications and compare the amount of detail you see at each level. When you reach the point where the overall image grows dimmer, look carefully and try even a little more power, because this is often the point where seeing faint features like spiral arms, knots, and dust lanes will be easier. Keep going and use your highest powers to examine the brightest parts of the galaxy like the nucleus and the prominent HII regions.

Numbers and Magnitudes

The table lists data for eighty-eight galaxies in Canes Venatici. Included are all those on the Tirion charts, plus about thirty more that are fainter than Tirion's cut-off magnitude. In the notes are some additional faint systems for which only magnitudes and relative coordinates are given.

The magnitudes of galaxies are problematic at best. The figures printed are from the most recently published sources, but keep in mind that many will appear fainter to your eye, especially face-on systems, dwarfs, and irregulars. Photographic magnitudes are marked with a "p" and tend to be fainter than what is seen at the eyepiece, so don't hesitate to search for a galaxy with a faint photographic magnitude. A 10-inch telescope will be able to show everything in Tirion plus a couple dozen more and should be able to reach at least some of the galaxies listed at magnitude 14.5p.

As long as this list is, it covers less than half the galaxies in *Uranometria 2000.0*. A 16-inch telescope should show most of these, but be forewarned that these charts include a number of dwarfs

The ninety bright galaxies in Canes Venatici vary from compact ellipticals to large, sprawling spirals. The tightly wound spiral M94 is a favorite object for galaxy observers because of its intensely bright and high surface brightness core. Photo by K. A. Brownlee, who used a 16-inch telescope.

with very low surface brightness that will challenge even the most experienced eye.

Observations and Descriptions

The galaxies in Canes Venatici are so numerous that a small book would be needed to describe them all. The selected descriptions of a couple dozen of the best that follow are based on observations through a 10-inch f/6 scope plus a few views with a friend's 17.5-inch telescope and will proceed through the constellation in a clockwise direction.

NGC 4528, a posthumous addition to Messier's list as **M106,** is one of the ten brightest galaxies in the northern sky. It has an intense, small but nonstellar nucleus in a very large, bright, oval halo. The two spiral arms are subtle at first but can be seen as brighter parts of the halo on the northwest and southeast sides with the northern arm somewhat brighter than the southern one.

Forming a triangle with M106 are **NGC 4217,** 35′ to the west-southwest, and **NGC 4220,** 45′ to the north-northwest. NGC 4217, an edge-on spiral, is quite diffuse and is more difficult than the magnitude would suggest. The middle is larger than the ends, and the dust lane that appears in photos can not be seen in the 10-inch instrument, but readers with larger scopes can look for it. NGC 4220 is an easily seen bright oval. Of the five faint galaxies around these, NGC 4218 and NGC 4226 could just be glimpsed in the 10-inch telescope. A look through a 17.5-inch scope also showed the close pair **NGC 4231** and **NGC 4232,** plus **NGC 4248.**

NGC 4242 is a face-on spiral of low surface brightness. It is slightly oval with a little brightening in the middle, and it is diffuse and featureless even in a 17.5-inch telescope. Several bright points suspected as knots or the nucleus were assumed to be foreground stars because they remained stellar under high magnification. Later examination of a photograph showed many small knots but no foreground stars, so perhaps I really saw the knots.

NGC 4449 is one of the little-known treasures in this part of the sky. It is brighter than most of the galaxies in Messier's catalogue, and it takes magnification very well. It is an irregular galaxy seen face-on and its structure is similar to that of the Large Magellanic Cloud with a large central bar and only weak suggestions of arms. The bar is seen as a bright rectangular area and the brightest arm is the one on the northwest side and it gives the galaxy a somewhat of an "L" shape in the 10-inch telescope. Viewing at high magnification will show the nucleus and many knots, which are more numerous in the northern part. In large scopes, look for a dust cloud on the eastern side of the bar.

Near the border where Canes Venatici and Ursa Major meet are three easily seen ellipticals: **NGC 4111, NGC 4138,** and **NGC 4143.** The edge-on spiral NGC 4183 is more difficult. This galaxy is misidentified as NGC 4160 in Burnham's, Tirion, and the older *Atlas Coeli.*

NGC 4490 and **NGC 4485** form a splendid interacting pair only a few arcminutes apart, which will keep them in the same field of view even at high power. The major axes of the galaxies are approximately at right angles to each other. NGC 4490 is larger and brighter and has a prominent bulge on the end that is near NGC 4485.

Another pair that may be interacting, **NGC 4618** and **NGC 4625,** are a couple of degrees to the west and are about 9′ apart. Both galaxies have similar redshifts and must be quite close to each other, but there is no detectable distortion of their shapes in a small scope.

If you usually pass up galaxy viewing because you have to observe from light-polluted areas, you will find **M94** (NGC 4736) worthwhile. It has a very intense nucleus surrounded by a bright, slightly oval glow. Visually it looks like an elliptical galaxy, because the dust that delineates the many spiral arms is not as dense as in many spirals. If you view from a dark site with a large scope, try to see a faint outer ring around the inner, brighter one.

NGC 4145 and **NGC 4151** are a pair less than a degree apart. NGC 4151 has a compact, bright central area in a very faint surrounding glow; NGC 4145 is visible as a large faint patch. In between there are three faint galaxies beyond the grasp of my 10-inch scope, but should be visible in a 16-inch scope. **NGC 4156** is on the northeast edge of NGC 4151, and the close pair NGC 4145A and UGC 7175 are 12′ southeast of NGC 4145.

It is interesting to compare **NGC 4244** with the classic edge-on spiral NGC 4565 in Coma Berenices. NGC 4244 appears as a straight streak of light that is a little brighter in the middle, lacking both the central bulge and the prominent dust lane that so many edge-on spirals like NGC 4565 are famous for.

NGC 4214 is an irregular galaxy seen as a stellar nucleus in a oblong bright patch. As in many irregular galaxies, there is a bar with weak, knotty arms. In very dark skies, look for faint extensions on the ends of the brightest area. Observers with large instruments should also try high magnification to see if any knots are visible.

NGC 4395 has a similar structure but covers such a large area that it is quite a challenge to see. For this galaxy as with other extended objects of low surface brightness, the size of your telescope doesn't matter, because the darkness of the sky will determine visibility. Although the galaxy will still be very faint, a large scope will let you search for HII regions. There are quite a few of them, three of which on the southeast side received their own numbers in Dreyer's catalogue: NGC 4399, NGC 4400, and NGC 4401.

Does anyone at your star parties ever show off **NGC 4631**? If you have seen it, you know it is one of the most interesting galaxies in the entire sky and that too few deep-sky watchers are aware of this wonderful sight. Like NGC 4244, it is an edge-on spiral without a nuclear bulge or dust lane. Irregular dust patches and star clouds can be seen along its length as areas of varying brightness, especially at higher magnification. There are also irregularities in the outline, similar to but not as prominent as those in M82.

That NGC 4631 is thicker on the eastern end and not straight along its length is caused by its interaction with **NGC 4656** about half a degree to the southeast. There is a third galaxy in this group, the small elliptical **NGC 4627,** which can be seen just slightly northwest of the center of NGC 4631. Between the center of NGC 4631 and NGC 4627 and just off the edge of the larger galaxy is a foreground star.

NGC 4656 appears as a long streak with a turn of 90° on the eastern end. There are several bright patches in the curve and the brightest one on the end is **NGC 4657,** which for many years was thought to be another galaxy interacting with NGC 4656, but recently research has shown that NGC 4656 is one galaxy distorted by a recent encounter with NGC 4631.

Radio observations show that two neutral hydrogen arms between the galaxies and both galaxies have distorted shapes. Interestingly, the bright streak we see is only half the galaxy. The brightest patch on the southwest end is actually the nucleus with the other half of the galaxy stretching farther to the southwest. Try searching this area for an extension of the visible part. It is very faint on photographs and I have never heard of a visual sighting.

Among all the galaxies in Canes Venatici are two star clusters in our own Galaxy. The open cluster **Upgren 1** is a coarse grouping of seven 7- to 10-magnitude stars, five of which are true members of the cluster. What we see is the remnant core of a very old cluster; its other members have long since disappeared.

Another unusual thing about this cluster is that it lies so far from the Milky Way: it is only 10° from the north galactic pole, which means it is almost directly above us as the Sun and the other stars in the galactic disk orbit the galactic center. There are only three

Galaxies in Canes Venatici

Designation	Right Ascension	Declination (2000.0)	Size	Mag.	Type	Notes
NGC 4111	12h07.1m	+43°04′	4.8′x1.1′	10.8	S0	4109, mag 15.1p, 6′ SSW
NGC 4117	12h07.8m	+43°08′	2.8′x1.1′	14.3p	S0	4118, mag 15.1p, 2′ SE
NGC 4138	12h09.5m	+43°41′	2.9′x1.9′	12.3	E4	
NGC 4143	12h09.6m	+42°32′	2.9′x1.8′	12.1	E4	
NGC 4145	12h10.0m	+39°53′	5.8′x4.4′	11.0	Sc	Low surface brightness
NGC 4151	12h10.5m	+39°24′	5.9′x4.4′	10.4	P	
NGC 4156	12h10.8m	+39°28′	1.5′x1.3′	13.0	SBb	on NE edge of 4151
UGC 7175	12h10.9m	+39°45′	2.1′x0.6′	14.9	S	4145A, mag 15.5p,1′ W
NGC 4163	12h12.2m	+36°10′	1.9′x1.7′	13.0	Irr	4148, mag 14.6p, 30′ SW
NGC 4183	12h13.3m	+43°42′	5.0′x0.9′	12.9	S	Mistaken for 4160 in Burnham and Tirion
NGC 4190	12h13.7m	+36°38′	1.7′x1.6′	13.3	Irr	
NGC 4214	12h15.6m	+36°20′	7.9′x6.3′	9.7	Irr	same as 4228; U727 mag 14.05, 25′ SSW
NGC 4217	12h15.8m	+47°06′	5.5′x1.8′	11.9	Sb	4426, mag 14.4p, 7′ SE
NGC 4220	12h16.2m	+47°53′	4.1′x1.5′	12.2	Sa	4218, mag 13.24, 15′ N
NGC 4227	12h16.5m	+33°31′	1.8′x1.1′	13.8p	Sa	4229, mag 14.3p, 3′ NE
NGC 4231	12h16.8m	+47°27′	1.4′x1.3′	14.5p	S0	4332, mag 14.6p, 1′ S
NGC 4242	12h17.5m	+45°37	4.8′x3.8′	11.0	S	Low surface brightness
NGC 4244	12h17.5m	+37°49′	16.2′x2.5′	10.2	S	
NGC 4248	12h17.8m	+47°25′	3.0′x1.2′	12.6	Irr	Low surface brightness
NGC 4258	12h19.0m	+47°18′	18.2′x7.9′	8.3	Sb	=M106
NGC 4288	12h20.6m	+46°17′	2.3′x1.7′	13.0	S	4288A, mag 15.0p, 3′ S
NGC 4346	12h23.5m	+47°00′	3.5′x1.4′	12.2	E6	
NGC 4357	12h24.0m	+48°46′	3.8′x1.5′	13.5p	Sb0	
NGC 4369	12h24.6m	+39°23′	2.5′x2.4′	11.8	Sa	
NGC 4389	12h25.6m	+45°41′	2.7′x1.5′	12.5	SB	4392, mag 14.6p, 11′ NNW
NGC 4395	12h25.8m	+33°33′	12.9′x11.0′	10.2	S	Very low surface brightness, contains H-II regions, 4399, 4400, and 4401
NGC 4449	12h28.2m	+44°06′	5.1′x3.7′	9.4	Irr	
NGC 4460	12h28.8m	+44°52′	4.4′x1.4′	12.3	SB0	
NGC 4485	12h30.5m	+41°42′	2.4′x1.7′	12.0	Irr	Interacting pair with 4490
NGC 4490	12h30.6m	+41°38′	5.9′x3.1′	9.8	Sc	Interacting pair with 4485
UGC 7699	12h32.8m	+37°37′	3.9′x1.2′	12.9	SBc	
NGC 4534	12h34.1m	+35°31′	3.0′x2.5′	12.3	Sd	Low surface brightness
Upgren 1	12h35.0m	+36°18′	15	7		Open Cluster
NGC 4618	12h41.5m	+41°09′	4.4′x3.8′	10.8	Sc	Possibly interacting with 4625
NGC 4619	12h41.7m	+35°04′	1.5′x1.5′	13.5p	SBb	
NGC 4625	12h41.9m	+41°16′	2.4′x2.0′	12.3	S	Possibly interacting with 4618
NGC 4627	12h42.0m	+32°34′	2.7′x2.0′	12.3	E4	Companion to 4631
NGC 4631	12h42.1m	+32°32′	15.1′x3.3′	9.3	Sc	Interacting with 4656
NGC 4656	12h44.0m	+32°10′	13.8′x3.3′	10.4	Sc	4657 is bright region on NE end; interacting with 4631
NGC 4736	12h50.9m	+41°07′	11.0′x9.1′	8.2	Sb	=M94
NGC 4800	12h54.6m	+46°32′	1.8′x1.4′	12.3	Sb	
NGC 4861	12h59.0m	+34°52′	4.1′x1.6′	12.2	Irr	Low surface brightness; a mag 13.2 HII region on SW end
NGC 4868	12h59.1m	+37°19′	1.7′x1.6′	13.1	Sb	
NGC 4914	13h00.7m	+37°19′	3.6′x2.2′	12.3	E2	
NGC 4956	13h05.0m	+35°11′	1.5′x1.5′	13.5p	S0	

Galaxies in Canes Venatici

Designation	Right Ascension	Declination (2000.0)	Size	Mag.	Type	Notes
IC 4182	13h05.8m	+37°36′	6.7′x5.9′	12.6	S	Low surface brightness
NGC 5005	13h10.9m	+37°03′	5.4′x2.7′	9.8	Sb	5002, mag 14.7p, 25′ S
NGC 5014	13h11.5m	+36°17′	1.7′x0.7′	13.5	Sa	U8303, mag 13.22, 20′ ESE
NGC 5023	13h12.2m	+44°02′	6.5′x1.0′	12.3	Sc	
NGC 5033	13h13.4m	+36°36′	10.5′x5.6′	10.1	Sb	
NGC 5055	13h15.8m	+42°02′	12.3′x7.6′	8.6	Sb	=M63
NGC 5074	13h18.4m	+31°28′	1.0′x1.0′	14.0	P	
NGC 5103	13h20.5m	+43°04′	1.5′x1.0′	13.6p	P	
NGC 5112	13h21.9m	+38°44′	3.9′x2.9′	11.9	Sc	5107, mag 13.66, 12′ SSW
NGC 5123	13h23.2m	+43°04′	1.4′x1.2′	13.5p	Sc	5145, mag 12.98, 25′ NE
NGC 5141	13h24.9m	+36°23′	1.7′x1.3′	12.8	S0	Low surface brightness; Markarian 451, mag 14.6p, 15′ NW
NGC 5142	13h25.0m	+36°24′	1.1′x0.8′	13.3	S0	5143, mag 15.5p, 2′ N; 5141, 2′ SW
NGC 5149	13h25.9m	+35°57′	1.6′x0.9′	13.8p	Sb	5154, mag 14.9p, 6′ NE
NGC 5173	13h28.4m	+46°36′	1.3′x1.3′	13.5	E0	5169, mag 14.47, 6′ NNW
NGC 5194	13h29.9m	+47°12′	11.0′x7.8′	8.4	Sc	=M51; interacting with 5195
NGC 5195	13h30.0m	+47°16′	5.4′x4.3′	9.6	P	Interacting companion to 5194
NGC 5198	13h30.2m	+46°40′	2.1′x1.9′	12.7	E2	
NGC 5272	13h42.2m	+28°23′	16′	6.4		Globular Cluster = M3
NGC 5273	13h42.1m	+35°39′	3.1′x2.7′	11.6	E1	5276, mag 14.6p, 4′ SE
NGC 5290	13h45.3m	+41°43′	3.7′x1.1′	12.6	Sb	5289, mag 13.5p, 13′ SSW
NGC 5297	13h46.4m	+43°52′	5.6′x1.4′	12.2	Sb	5296, mag 14,70, 2′ SSW
NGC 5301	13h46.4m	+46°06′	4.4′x1.1′	12.6	Sb	
NGC 5303	13h47.8m	+38°18′	1.1′x1.0′	12.0p	P	5303B, mag 15.3p, 4′ S
NGC 5313	13h49.7m	+39°59′	1.9′x1.2′	12.6	Sb	5311, mag 13.6p, 10′ W
NGC 5318	13h50.6m	+33°42′	1.5′x0.9′	13.5p	S0	5319, mag 15.0p, very close to E
NGC 5320	13h50.3m	+41°22′	3.5′x1.9′	12.7	Sc	
NGC 5326	13h50.8m	+39°34′	2.5′x1.3′	12.9	Sb	I4336, mag 14.6p, 12′ N
NGC 5336	13h52.2m	+43°14′	1.6′x1.3′	13.6p	Sc	U8733, mag 13.60, 40′ WNW
NGC 5337	13h52.4m	+39°41′	1.8′x0.8′	13.4p	S	5346, mag 14.9p, 10′ SE
NGC 5347	13h53.3m	+33°29′	1.9′x1.5′	12.6	Sb	U8825, mag 14.4p, 7′ NE
NGC 5350	13h53.4m	+40°22′	3.2′x2.6′	11.4	Sb	In a group of 5
NGC 5351	13h53.5m	+37°55′	3.1′x1.8′	12.1	Sb	5341, mag 14.1p, 12′ SW; 5349, mag 15.1p, 4′ SW
NGC 5353	13h53.5m	+40°17′	2.8′x1.5′	11.1	E5	5358, mag 14.6p, 5′ E, both in a group of 5
NGC 5354	13h53.5m	+40°18′	2.3′x2.0′	11.5	S0	5355, mag 14.0p, 3′ NE, both in a group of 5
NGC 5362	13h54.9m	+41°19′	2.4′x1.1′	13.1	Sb	
NGC 5371	13h55.7m	+40°28′	4.4′x3.6′	10.8	Sb	same as 5390
NGC 5375	13h56.8m	+29°10′	3.5′x3.0′	12.3	SBb	
NGC 5377	13h56.3m	+47°14′	4.6′x2.7′	11.2	Sa	
NGC 5380	13h56.9m	+37°37′	2.1′x2.1′	12.8	Sa	5378, mag 13.8p, 12′ N
NGC 5383	13h57.1m	+41°51′	3.5′x3.1′	11.4	SBb	
NGC 5394	13h58.6m	+37°27′	1.9′x1.1′	13.0	SBb	Connected to 5395
NGC 5395	13h58.6m	+37°25′	3.1′x1.7′	11.6	Sb	Connected to 5394
NGC 5406	14h00.3m	+38°55′	2.1′x1.6′	13.0	Sb	5407, mag 14.5p, 15′ NNE
NGC 5440	14h03.0m	+34°46′	3.3′x1.4′	13.4p	Sa	5441, mag 15.5p, 5′ SSE
NGC 5444	14h03.4m	+35°08′	2.7′x2.3′	12.5	E1	5445, mag 14.1p, 7′ S

Left: One of the oddest groups of galaxies in the sky is that made up of the edge-on spiral NGC 4631 (top) and NGC 4656, which lies about 30′ southwest (bottom). These galaxies are gravitationally interacting, which causes a tidal distortion in both systems. The tiny elliptical NGC 4627 orbits NGC 4631, while the bright region on the northeastern end of NGC 4656 has the separate designation of NGC 4657. Photo by Martin C. Germano, who used an 8-inch f/5 Newtonian, hypersensitized Tech Pan, and a 50-minute exposure.

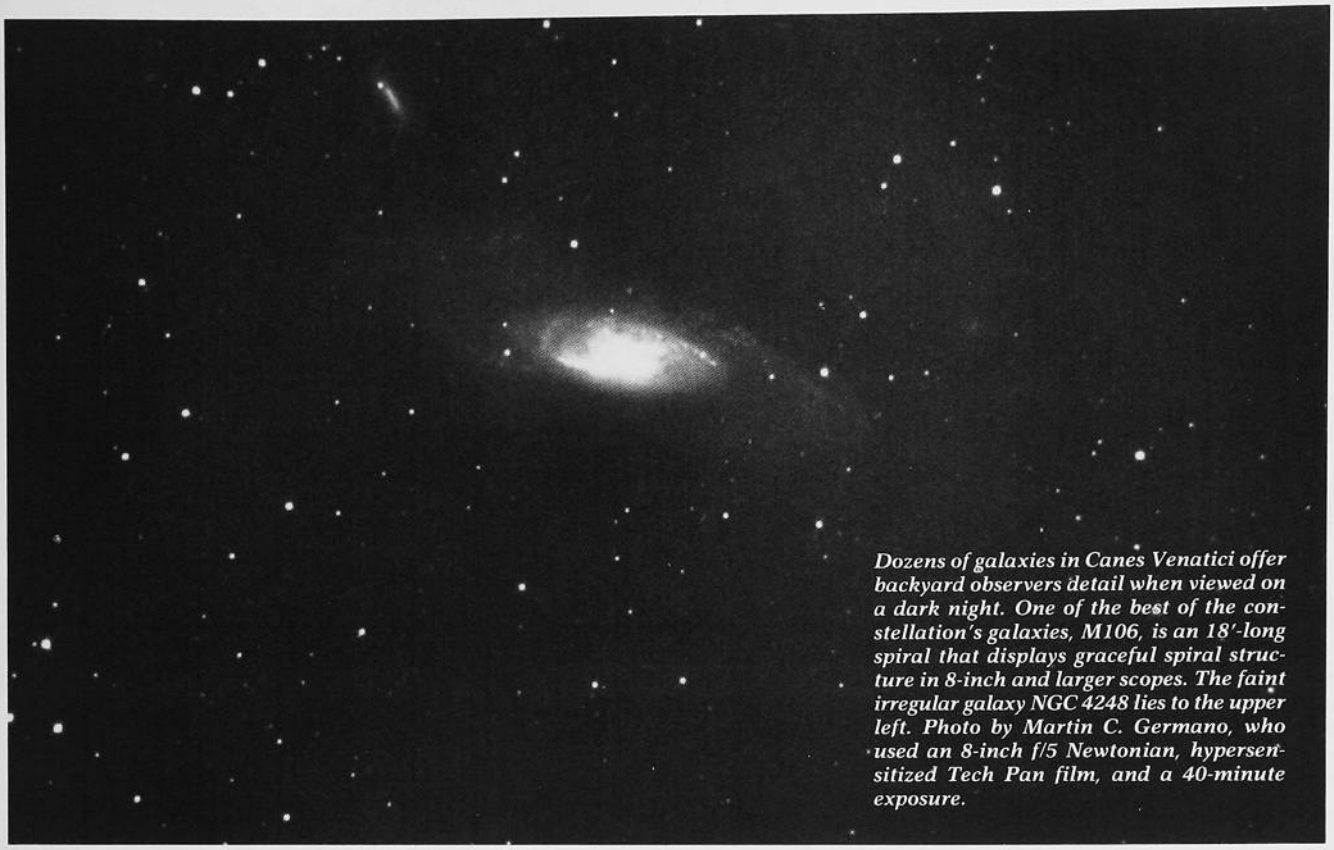
Top: The edge-on spiral NGC 4244 is only slightly brighter in its middle than at its edges and has a tiny stellar core. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, 103a-F film, and a 75-minute exposure.

Above center: One of the best examples of an irregular galaxy is NGC 4449, an object that appears square-shaped in a 6-inch telescope. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, 103a-F film, and a 70-minute exposure.

Above: NGC 5005 is an oval-shaped galaxy measuring 5′ across. Photo by Lee C. Coombs, who used a 10-inch f/5 Newtonian, 103a-O film, and a 15-minute exposure.

M64, the Blackeye Galaxy, is characterized by the broad patch of dust that obscures part of the galaxy's nuclear bulge. This feature is visible in a 6-inch telescope. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, hypersensitized Tech Pan film, and a 75-minute exposure.

Inset: The pair of interacting galaxies NGC 4485 (left) and NGC 4490 is visible in a 6-inch scope as a faint double patch of nebulosity. Photo by K. A. Brownlee, who used a 16-inch telescope.



Dozens of galaxies in Canes Venatici offer backyard observers detail when viewed on a dark night. One of the best of the constellation's galaxies, M106, is an 18'-long spiral that displays graceful spiral structure in 8-inch and larger scopes. The faint irregular galaxy NGC 4248 lies to the upper left. Photo by Martin C. Germano, who used an 8-inch f/5 Newtonian, hypersensitized Tech Pan film, and a 40-minute exposure.

clusters closer to us than Upgren 1, two of which, the Coma Berenices cluster and the Ursa Major cluster, are in the same part of the sky.

About one hundred times farther away is the brilliant globular, **M3** (NGC 5272), only slightly fainter than the summertime favorites, M5 and M13. M3 is easily resolved in small scopes, and it is a stunning sight in the 10-inch scope at 150x. Although it is not as well known as some of the summertime globulars, M3 is one of the best globulars visible to northern observers.

NGC 4861 is another irregular galaxy with a structure like that of the Large Magellanic Cloud. The galaxy itself has a very low surface brightness and is hard to see, but on the southwest end there is a giant HII region that is easier to see than the rest of the galaxy. There is a foreground star on the northeast end. This galaxy also appears in the Index Catalogue as IC 3961, and you will sometimes see one number given to the galaxy and the other to the HII region, but the original description in Dreyer's catalogue fits the galaxy.

The numerous galaxies in the eastern part of Canes Venatici are more distant and will show detail in smaller telescopes. It is a rich area and one worth your while to explore, but detailed notes will have to wait for another time. A good place to start exploring this area is with the bright spiral **NGC 5371.** About half a degree to the west-southwest is a group of five galaxies within a span of 10'. The three brightest from north to south are **NGC 5350, NGC 5354,** and **NGC 5353.** Just to the east is **NGC 5355,** and to the southeast is the faintest, **NGC 5358.** The first four were easily seen in a 10-inch telescope, although the fifth may require a couple more inches of aperture.

NGC 5005 and **NGC 5033** are two nice spirals 40' apart. Both appear as ovals rapidly increasing in brightness to the middle. Three fainter systems are nearby. The brightest, **NGC 5014,** is 30' southwest of NGC 5033. The two fainter galaxies, **NGC 5002,** 25' south of NGC 5005, and **UGC 8303,** 25' south of 5033, will probably need a 12-inch telescope to be seen.

It is interesting to compare **M63** (NGC 5055) with M94 because both are many-armed spirals. M63 is more elongated because it is more highly inclined to our line of sight and the nucleus is less intense than M94. M63 also shows more distinct zones of decreasing brightness — at least three when the central area is viewed at high power. In both galaxies the dust lanes are not dense enough to appear as dark streaks, but look for areas surrounding the nucleus.

The reasons for the popularity of **M51** (NGC 5194) are not hard to understand. M51 is the perfect textbook illustration of spiral structure and one of the few galaxies where seeing the spiral pattern is easy at the eyepiece. In addition it has a bright interacting companion apparently connected to the end of one of the arms. What is the smallest aperture needed to see the arms? Although some brightness variations may be seen in smaller scopes, I would say 8 inches are necessary to really follow them for any length and then only in very good conditions. The brightest arm is the one between the nucleus of the larger galaxy and the companion. If you see this try following it around and then try spotting the other arm that goes out to the companion. When looking for the bridge, try to be honest about whether you truly see it or are remembering it from photographs. With a 10-inch telescope I have not been sure I have seen it, because it is a subtle feature clearly seen only in larger instruments. As with most galaxy features, the spiral arms are easiest to see when the galaxy is magnified to the point where it appears dimmer.

After viewing M51, you might want to try for three faint galaxies nearby. NGC 5198 is half a degree south of M51, and 20' west of it is the pair 5169 and 5173. All are small and faint but within the grasp of a 10-inch scope.

Beyond the galaxies described, there are several dozen more that can be seen with 8- to 10-inch scopes, and this only scratches the surface of the possibilities of an instrument with twice the aperture. Good luck as you explore this fascinating area of the sky.

Max Radloff lives in South St. Paul, Minnesota. A musician by profession, he revived his childhood interest in astronomy about ten years ago. He is secretary of the Minnesota Astronomical Society and writes a deep-sky column for its newsletter, "Gemini."

Pushing to the Limit: The Palomar Clusters from Your Backyard

by David Higgins

Globular clusters are stunning objects in large telescopes. Stars fill the field of view by the thousands, gleaming yellow-orange in every direction the eye glances. "Dark lanes" wind in and out of little groups of stars that punctuate apparent voids in the clusters' memberships. Whether you're a first-time viewer or an old hand, after viewing a globular you come away with a profound feeling that you've just peered at tens of thousands of distant worlds.

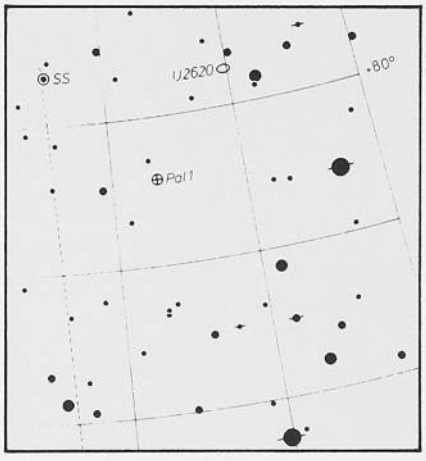
About 150 globular clusters lie scattered across the sky, most of them concentrated in the Ophiuchus-Scorpius-Sagittarius region. Many of these magnificent globes of stars are visible in just about any backyard scope, and a few can even be glimpsed with the naked eye (although they look like stars). However, a select group of extremely faint globular clusters discovered during the first Palomar Sky Survey (POSS), the so-called Palomar Clusters, offers an extreme observational challenge to owners of large backyard telescopes. At least five of these remote globulars are visible in large amateur instruments. Before examining the prospects for observing these ignored deep-sky wonders, let's put their astrophysical nature in perspective.

The Allure of Globular Clusters

It's no wonder globular clusters hold such a fascination for astronomers, because unraveling the nature of globular clusters has contributed a great deal to our understanding of the universe.

In 1917 Harlow Shapley was hard at work studying globular clusters. He catalogued globular clusters and found most lay in one small part of the sky toward Sagittarius. This puzzled him, and he set about trying to deduce the distribution of these clusters. How distant were these groups of stars? How were they distributed in the Milky Way?

Shapley noticed that globulars contained not only red giants and supergiants but also members of a class of odd variables called RR Lyrae stars. These stars have a well-known period-luminosity relationship and so can be used as distance calibrators throughout the Galaxy and in globulars. After recognizing stars in globulars as RR Lyrae objects, Shapley used a simple equation to compute their distances and therefore the distances to the globular clusters. He



The fifteen globular clusters discovered and catalogued at Palomar Observatory will challenge large telescope owners to the utmost of their ability. Palomar 1 is circumpolar for northern observers, lying 1° southwest of the variable star SS Cephei. But it is exceedingly faint and seeing it will require a 16-inch or larger telescope. Chart from **Uranometria 2000.0**, *copyright 1987 Wilmann-Bell, Inc.*

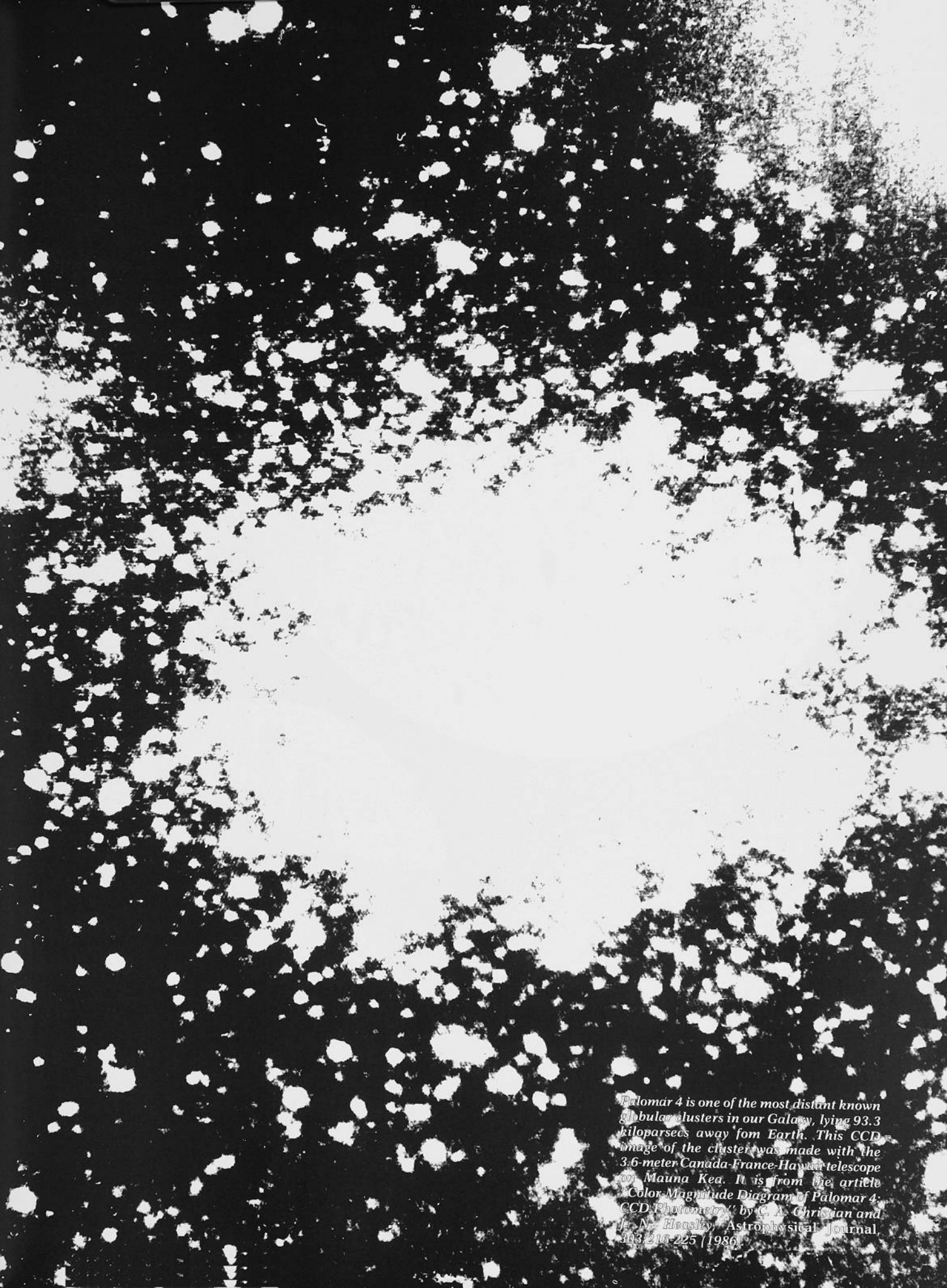
did this by knowing the absolute magnitudes of RR Lyrae stars and observing their apparent magnitudes over time. Once Shapley calculated the distances to a great number of globulars, he knew the globulars were distributed about the center of the Galaxy, which lay in Sagittarius. Shapley also found that the Sun is located well away from the galactic center, which killed one of the last "man has the central place in the universe" claims. We now know the Sun is 8.5 kiloparsecs away from the galactic center.

Globular star clusters are the oldest objects in the universe, some dating back to shortly after the Big Bang. Because of this, globulars are rich storehouses of information on how stars evolve and why they differ in temperature, brightness, and mass. Because of their great age, globulars set a lower limit on the age of the universe itself. Furthermore, globulars offer clues about how the galaxies they still orbit formed.

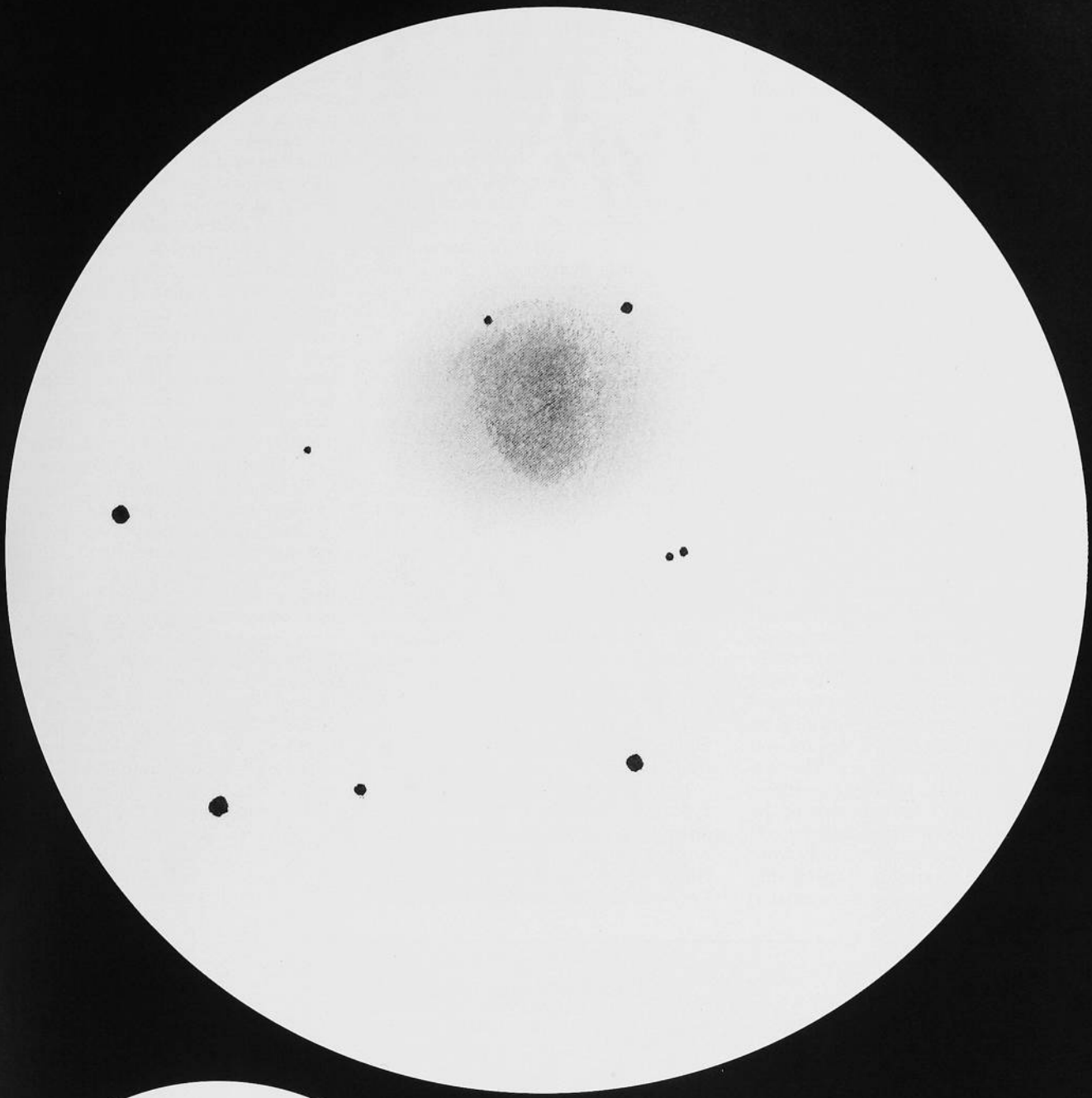
The scenario of globular cluster formation probably went something like this: After the Big Bang, large masses of hydrogen and trace amounts of helium began to fragment into enormous clouds. The size of these clouds was determined by the balance achieved between gravity, which tended to condense the gas, and heat, which tended to disperse it. Almost certainly some of these pregalactic clouds were the size of healthy globular clusters. Over time these clouds drifted together by mutual gravitational attraction, most forming large clouds that became galaxies. However, some of them escaped this coalescing and remained gravitationally bound to the galaxies, thus becoming globular clusters.

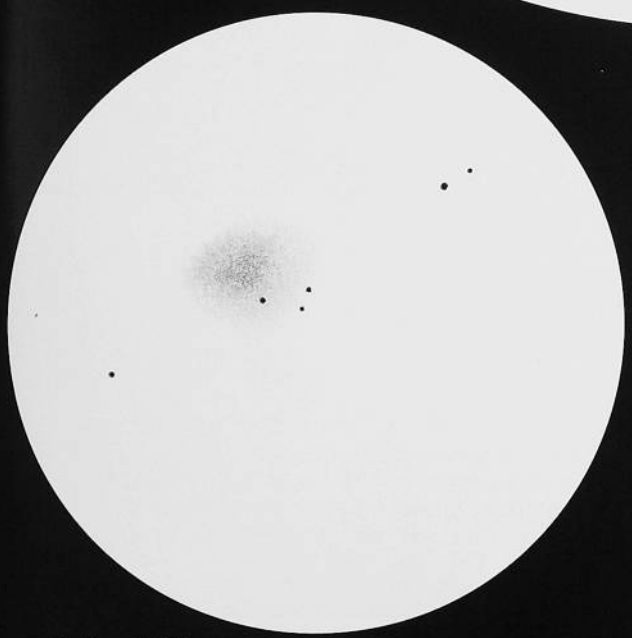
Globular clusters are metal poor, which means they contain a very low ratio of heavy elements to hydrogen in their stars. The stars in globulars are old Population II stars that have used much of their hydrogen fuel. So what has happened to the heavy elements produced by fusion reactions in globular cluster stars? Globular clusters orbit about the galactic center and occasionally each plunges through the disk of the Milky Way. This sweeps out dust and gas from inside the globulars and leaves it in the disk of the Galaxy, thereby stripping globulars of heavy metals.

The Milky Way lacks the large complement of globular clusters visible in



Palomar 4 is one of the most distant known globular clusters in our Galaxy, lying 93.3 kiloparsecs away fom Earth. This CCD image of the cluster was made with the 3.6-meter Canada-France-Hawaii telescope on Mauna Kea. It is from the article "Color-Magnitude Diagram of Palomar 4: CCD Photometry" by C. A. Christian and J. N. Heasley, Astrophysical Journal, 303:216-225 (1986).





Top left: With an integrated magnitude of 9.8, Palomar 11 in Aquila is the second brightest cluster in the Palomar catalogue. A large telescope shows the globular as a reasonably bright disk of light without individual stars. All sketches have south at top and west to the left. David Higgins used a 24-inch f/4 Newtonian for all five renderings. For this sketch Higgins used 187x, which yielded a field 26′ across.

Above: Located only 2.5° southeast of the great open cluster M25 in Sagittarius, Palomar 8 is bright enough to be glimpsed with moderate-sized instruments. This sketch was made at 270x.

Far left: Palomar 7 in Serpens Cauda is best visible at low powers. The cluster appears as a "low surface brightness haze with a faint field star on its southern edge." This sketch was made at 76x, which gives a field of 48′.

Left center: Palomar 9, also in Sagittarius, is the brightest and easiest to observe of all the Palomar clusters. According to Higgins, "This was the only Palomar cluster that looked like a globular in the telescope." Higgins sketched Palomar 9 at 270x.

Left: Well placed for viewing near M10 and M12 in Ophiuchus, the distant globular Palomar 15 is a real challenge for large scopes. The surface brightness of Palomar 15's core is only 16.0. Sketch made at 270x, which resulted in an 18′ field.

some other galaxies. Our Galaxy contains approximately 150 known globulars; certainly many more are obscured by thick veils of interstellar dust. Others are possibly so distant that they are exceedingly faint if obscured at all. Several known globular clusters lie at distances well over 100 kiloparsecs from the galactic center. The Magellanic Clouds, as a comparison, lie approximately 50 and 60 kiloparsecs from the center of the Galaxy.

New Globulars for the Twentieth Century

Nearly all of the 150 Milky Way globulars are visible in small telescopes. (See the previous article by F. Michael Witkoski for a representative sample.) But a number of faint globulars clusters discovered in the 1950s on plates made for the Palomar Observatory Sky Survey offer a real challenge to users of large telescopes. The story of these objects, rarely mentioned in the astronomical literature, is a fascinating tale of discovery.

With the bulk of the Palomar Sky Survey completed, astronomers were confronted in 1954 with a vast amount of extragalactic objects to observe and study. Many of these objects had never been photographed so well or were unknown before the Sky Survey plates were made. Astronomers working on the survey plotted galaxies, clusters, and nebulae with great accuracy. The survey's 1,870 plates, half blue sensitive and half red, gave astronomers for the first time a uniform, dependable record of how the sky appears. Not only were the survey plates useful in measuring positions of objects with great accuracy, but they gave researchers a starting place for deciphering the nature of newly discovered objects.

Among all of the new objects found on the Palomar Sky Survey, fifteen new globular clusters were suspected. By 1955, thirteen suspected globulars were photographed with the 5-meter Hale telescope for verification. Because of their great distances, the images of these clusters on the POSS consisted of small, fuzzy dots. The thirteen suspects were subsequently identified as globulars, the faintest such objects recorded up until that date. The list of astronomers who identified the objects reads like a "Who's Who" of astronomy. The clusters Palomar 2 (Auriga), Palomar 3 (Sextans), Palomar 10 (Sagitta), Palomar 11 (Aquila), and Palomar 13 (Pegasus) were identified by Albert G. Wilson. Wilson and Edwin Hubble identified Palomar 4 (Ursa Major). Wilson and Walter Baade recognized Palomar 5 (Serpens) as a globular. Palomar 12 (Capricornus) was identified by Robert G. Harrington and Fritz Zwicky. George O. Abell discovered Palomar 1 (Cepheus), Palomar 6 (Ophiuchus), Palomar 7 (Serpens), Palomar 8 (Sagittarius), and Palomar 9 (Sagittarius). Several years later, in 1960, Halton C. Arp and Sidney van den Bergh found another such cluster, Palomar 14 (Hercules). Palomar 15 (in Ophiuchus, near M10) was discovered by Fritz Zwicky soon afterward.

The Palomar clusters are a varied lot. Palomar 6, Palomar 7, Palomar 9, Palomar 10, and Palomar 11 are relatively nearby objects of average globular cluster size that just happen to be heavily obscured by line-of-sight dust. Twice as distant but still typical globulars are Palomar 1, Palomar 2, Palomar 8, and Palomar 13; these objects also suffer from high obscuration. Palomar 5 is an enormous halo globular measuring 225 parsecs across; this object lies only 21 kiloparsecs away but is heavily obscured by dust. Palomar 12 is a large (120 parsec-diameter) globular lying nearly 20 kiloparsecs away.

Several of the Palomar clusters are among the largest and most distant globular clusters yet observed in the Milky Way. Palomar 15 measures 220 parsecs across and lies at a distance of nearly 70 kiloparsecs. Palomar 14 is very similar, spanning 205 parsecs and lying 75 kiloparsecs distant. Palomar 3 measures 220 parsecs across and is located 88 kiloparsecs away. Palomar 4, the most distant of the Palomar clusters, lies 93 kiloparsecs away from the Sun and measures 170 parsecs across.

Observing the Palomar Clusters

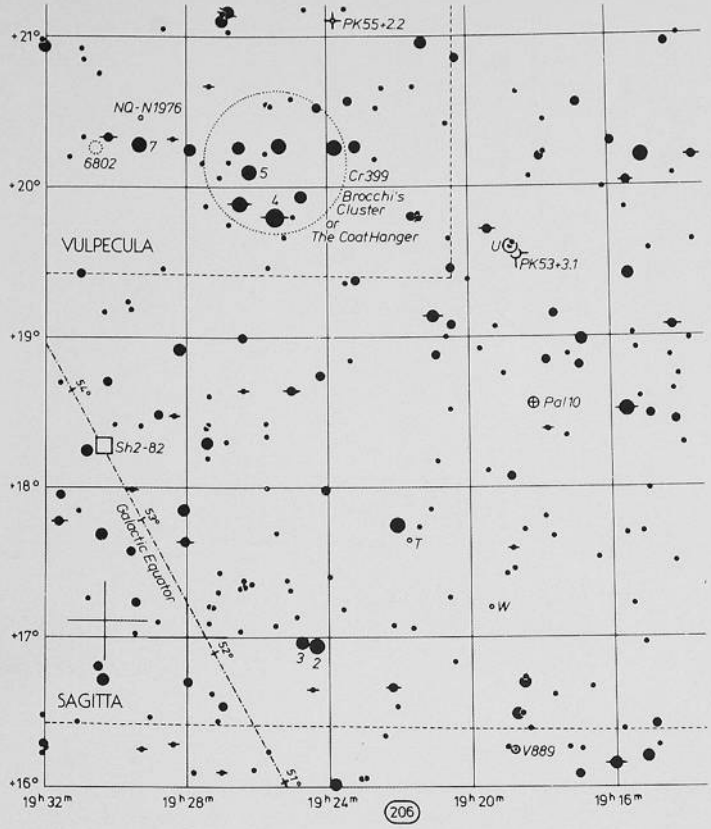
After years of neglect in popular astronomical literature the Palomar clusters are finally getting some attention. *Sky Catalogue 2000.0* lists the fifteen objects and gives positions and sizes for the clusters but not magnitudes. The best sources for globular cluster data are two professional papers, Gonzalo Alcaino's "Basic Data for Galactic Globular Clusters" in the *Publications of the Astronomical Society of the Pacific*, August 1977, and Ronald Webbink's "Structure Parameters of Galactic Globular Clusters" in *Dynamics of Star Clusters*, the proceedings volume for IAU symposium 113 (D. Reidel, Dordrecht, Holland, 1984). As it is the most current, the Webbink paper is

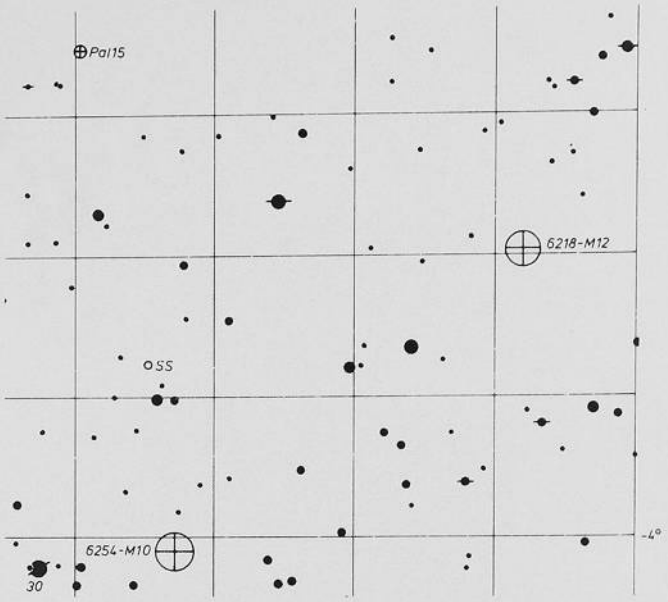
The Palomar Clusters

Designation	R.A. (2000.0)	Dec.	Mag.^{V}	SB^{C}	Con.	Size	Diameter	Distance^{GC}	Distance$^{\odot}$	N$^{VAR.}$
Palomar 1	3h33.2m	+79°35′	13.6	12.4	Cep	1.8′	40 pc	20.3 kpc	13.7 kpc	—
Palomar 2	4h46.1m	+31°23′	13.0	10.5:	Aur	1.9′	25 pc	22.2 kpc	13.6 kpc	—
Palomar 3	10h05.5m	+0°04′	13.9:	14.2	Sex	2.8′	220 pc	91.5 kpc	87.9 kpc	1
Palomar 4	11h29.3m	+28°58′	14.2	14.4	UMa	2.1′	170 pc	96.2 kpc	93.3 kpc	2
Palomar 5	15h16.1m	−0°07′	11.8	15.7	Ser	6.9′	225 pc	16.5 kpc	21.4 kpc	5
Palomar 14	16h11.1m	+14°57′	14.7	15.7	Her	2.1′	205 pc	69.9 kpc	75.3 kpc	—
*Palomar 15	16h59.9m	−0°32′	14.2	16.0	Oph	4.2′	220 pc	62.3 kpc	69.7 kpc	—
Palomar 6	17h43.7m	−26°13′	11.6:	12.8	Oph	7.2′	25 pc	2.9 kpc	5.9 kpc	—
*Palomar 7	18h10.7m	−7°12′	10.3:	12.8	Ser	7.1′	70 pc	3.8 kpc	9.8 kpc	5
*Palomar 8	18h41.0m	−19°49′	11.2	10.9	Sgr	4.7′	35 pc	19.8 kpc	28.1 kpc	—
*Palomar 9	18h55.1m	−22°42′	9.2	7.3	Sgr	3.9′	35 pc	2.6 kpc	7.8 kpc	—
Palomar 10	19h18.2m	+18°34′	13.2	13.1	Sge	3.5′	35 pc	8.7 kpc	10.6 kpc	—
*Palomar 11	19h45.3m	+8°02′	9.8:	11.9	Aql	3.2′	60 pc	8.3 kpc	13.8 kpc	—
Palomar 12	21h46.5m	−21°14′	11.7	12.9	Cap	2.9′	120 pc	16.0 kpc	19.4 kpc	3
Palomar 13	23h06.7m	+12°46′	13.8:	13.5:	Peg	1.8′	60 pc	25.7 kpc	24.4 kpc	4

*Asterisk denotes successful observation by Higgins.

Designation: Number in Palomar catalogue. **R.A.** and **Dec.:** Coordinates for epoch 2000.0. **Mag.^{V}:** V magnitude of cluster. **SB^{C}:** Surface brightness in magnitudes per square arcminute measured at cluster's core. **Con:** Constellation in which cluster lies. **Size:** Angular size in arcminutes. **Diameter:** Linear diameter in parsecs. **Distance^{GC}:** Distance from cluster to galactic center. **Distance$^{\odot}$:** Distance from cluster to the Sun. **N$^{VAR.}$:** Number of known variables in cluster.





Left: The faint cluster Palomar 10 lies in Sagitta, 2° southwest of Brocchi's cluster. Although its position is rather easy to locate, the globular itself is extremely challenging.

Above: Palomar 15 lies only several degrees northeast of the bright globulars M10 and M12 in Ophiuchus, but the Palomar cluster is nonetheless very elusive. Charts from **Uranometria 2000.0,** *copyright 1987 Wilmann-Bell, Inc.*

probably the most useful. Information from both papers, including magnitudes and cord surface brightnesses, appears in the table on page 20.

The Palomar clusters are not plotted on *Sky Atlas 2000.0*. If this is your primary atlas, you'll have to plot the clusters by hand with the coordinates in the accompanying table. However, *Uranometria 2000.0* does show the positions of the Palomar clusters, so if you have a copy of this atlas, you're all set.

Because the Palomar clusters are either extremely distant or heavily obscured, they pose quite a challenge to users of large backyard telescopes. In fact, of the five Palomar clusters I've managed to track down so far, only one, Palomar 9, appeared remotely like a globular cluster. The others appeared like exceedingly dim patches of haze that resembled small nebulae. Averted vision was necessary to glimpse some of them. And I was using a 24-inch f/4 telescope. However, observers, telescopes, and observing conditions vary so widely that some of these objects may be visible with a 12-inch scope under excellent conditions.

Palomar 7. This highly obscured cluster lies in Serpens Cauda and is also known as IC 1276. Palomar 7's total magnitude is thought to be 10.3, and its core has a surface brightness of 12.8 magnitudes per arcminute. This cluster lies 9.8 kiloparsecs away from the Sun but only 3.8 kiloparsecs away from the center of the Galaxy. Palomar 7's size is 7.1', which corresponds to a large physical diameter of 70 kiloparsecs.

Located only 1.5° east of the globular cluster NGC 6539, Palomar 7 seems to be best visible at low powers in the 24-inch telescope. A 32mm wide field eyepiece yields 76x; this magnification and averted vision show the cluster. Palomar 7 appears as a large, low surface brightness haze with a faint field star on the cluster's southern edge.

Palomar 8. This cluster lies in Sagittarius about 2.5° southeast of the bright star cluster M25. Palomar 8 is very heavily obscured, as it lies 28.1 kiloparsecs away, almost directly in back of the galactic center. The magnitude of Palomar 8 is 11.2 and its core surface brightness 10.2. Because the cluster spans 4.7', the light from it is spread out and difficult to see. Low magnifications will not show this group. I used a 9mm Nagler eyepiece to yield 270x, which showed Palomar 8 as a faint wisp of nebulosity.

Palomar 9. This is the only Palomar cluster that resembled a globular in my telescope. Palomar 9 is a normal size globular lying behind heavy blankets of dust in Sagittarius, just east of Nu (ν) Sagittarii. Palomar 9 didn't appear resolved, but it did show an almost stellar core surrounded by a very faint haze. The total magnitude of this cluster is 9.2, and its core surface brightness 7.3. This cluster is the brightest and easiest of the Palomar clusters.

Palomar 11. Aquila's Palomar 11 is a large, obscured globular lying 13.8 kiloparsecs away. Located midway between 39 and 57 Aquilae, the globular's position is not difficult to find. However, the cluster is very faint and small, and I needed averted vision to spot it. A 13mm Nagler eyepiece gave the best view, and I suspect you will need to use high magnification on this object to see it well.

Palomar 15. The last of the Palomar clusters to be discovered, Palomar 15, is an enormous globular cluster lying an impressive 70 kiloparsecs away in the direction of Ophiuchus. Look for this cluster just over 2° southeast of 21 Ophiuchi in a field devoid of bright stars. Palomar 15 is extremely faint and requires high magnification. A faint field star lies just north of the cluster.

Although the Palomar clusters are extremely challenging for even large backyard telescopes, they offer an exciting project for the warm evenings of spring and early summer. I haven't had the time to try to find these objects with telescopes smaller than the 24-inch I used, but I would guess that quite a few readers will be able to see the Palomar clusters with 17.5-inch, 16-inch, and perhaps even 12-inch scopes. Let us know how you do.

David Higgins is the Central Coordinator of the National Deep Sky Observer's Society. His last article was "A Viewing Guide to E. E. Barnard's Dark Nebulae" in the Summer 1987 Deep Sky.

Observing the Centaurus Galaxy Cluster

by Jeffrey Corder

The southern constellation Centaurus is famous among amateur astronomers as the home of the bright and beautiful globular cluster Omega Centauri. Yet Centaurus also plays host to a diversified collection of other deep-sky objects. This includes at least fifty relatively bright NGC galaxies and open clusters, not to mention our stellar neighbor Alpha Centauri. (A good observing list of Centaurus objects appears in Jim Barclay's Spring 1985 *Deep Sky* article.)

Recently astronomers have focused attention on an intriguing cluster of galaxies centered 9° northwest of Omega Centauri. Called the Centaurus galaxy cluster, this gravitationally bound galaxy melange contains more than 250 members in a 30° by 20° area of sky. It is a loosely structured group, dominated by faint elliptical galaxies typical of evolutionary youth.

The Centaurus cluster is the dominant component of an even larger cluster complex that spans nearly 60° east to west across the southern sky from Antlia and Hydra throughout much of Centaurus. This macroscopic assemblage of galaxy clusters is called a supercluster. Some members of the Centaurus supercluster are the IC 4329 cluster (see Spring 1986 *Deep Sky*), the Hydra I complex (Abell 1060) and the NGC 4936 and IC 4296 groups in Centaurus.

Recent findings indicate that the Centaurus cluster is related to northern galaxy clusters and groups. Theories are currently being debated, but it seems quite probable that the Centaurus cluster is physically and gravitationally related to our own Local Group of galaxies and other groups, including the nearby Virgo supercluster. Apparently the Milky Way Galaxy lies in the midst of a huge cosmological triangle of galaxy clusters formed into one enormous conglomeration. If it exists, this gigantic cluster, which includes the Centaurus cluster, is the largest-scale structure in the universe yet observed by man.

Because of the lack of major observatories in the Southern Hemisphere before the 1970s, the Centaurus cluster has only recently been extensively photographed and studied by astronomers. Yet, because this cluster lies practically in our galactic backyard, only about twice as distant as the Virgo cluster, observers with moderate-sized telescopes can explore it quite thoroughly. The only drawback for northern observers is the cluster's deep southerly declination.

The Centaurus cluster is normal in many respects, yet unusual in others. Galaxy clusters are classed according to such criteria as their sizes, richnesses, distances, and ratios of galaxy types. The Centaurus cluster is about average in all of these areas. In fact, some interest is generated by the belief that this cluster could be a valuable morphological link between near, fairly rich clusters dominated by spirals and distant, extremely rich, elliptical-dominated clusters like Abell 1656 in Coma Berenices.

On the unusual side of things the Centaurus cluster has been identified as a strong source of both radio waves and x-rays. The cluster has a "double center," with most members primarily congregating around the galaxies NGC 4696 and NGC 4709.

NGC 4696 is the brightest and largest galaxy in the cluster, and because it is plotted on star atlases, it can be used to locate the cluster. This 11th-magnitude elliptical galaxy appears to be an active emitter of radio waves and x-rays, possibly accounting for 25 percent of the emission observed within the cluster. Deep photographs of the galaxy reveal dark lanes and filaments of nebulous material associated with the galaxy, which give the galaxy an appearance much like the active galaxy M87 in Virgo.

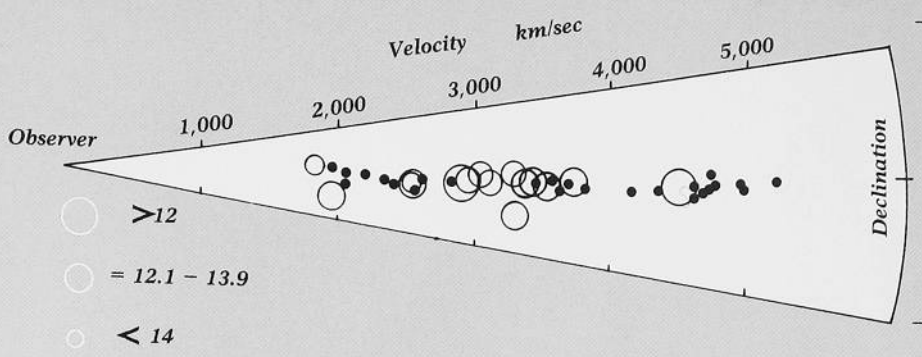
To visual observers, NGC 4696 is elongated almost exactly east-west and appears large and bright, about 90″ by 70″ in extent. The galaxy contains a very dense and bright core about 30″ across. A 14th-magnitude star lies at its northwestern edge.

Nearby, **NGC 4709** is only slightly fainter. It shines at 12th magnitude and its 60″ disk appears nearly round in shape. Like its neighbor to the west, NGC 4709 contains a bright, round core about 30″ across. The galaxy is conveniently situated just southwest of a prominent grouping of four 13th-magnitude stars.

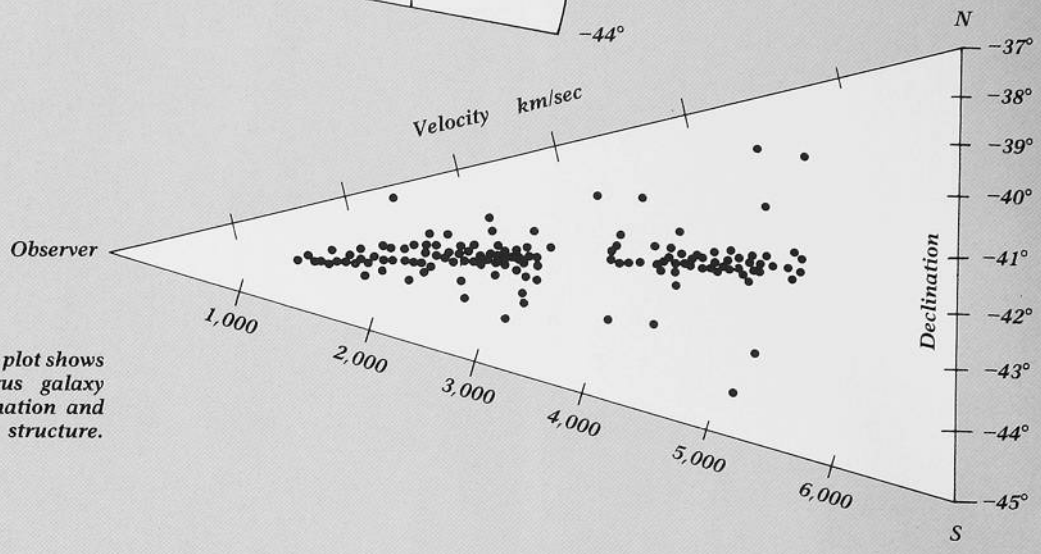
A fairly bright galaxy trio lies 30′ southwest of NGC 4696. The brightest of these is **NGC 4683**. At magnitude 13.5, this S0-type galaxy appears rather faint in medium-sized telescopes. It is slightly elongated to the northwest-southeast, measures 35″ by 30″ in overall size, and contains a very faint, stellar nucleus.

The second galaxy of the trio, **NGC 4677**, can be found just west of NGC 4683. It is a lenticular S0-type galaxy that shines at magnitude 13.6. Visually

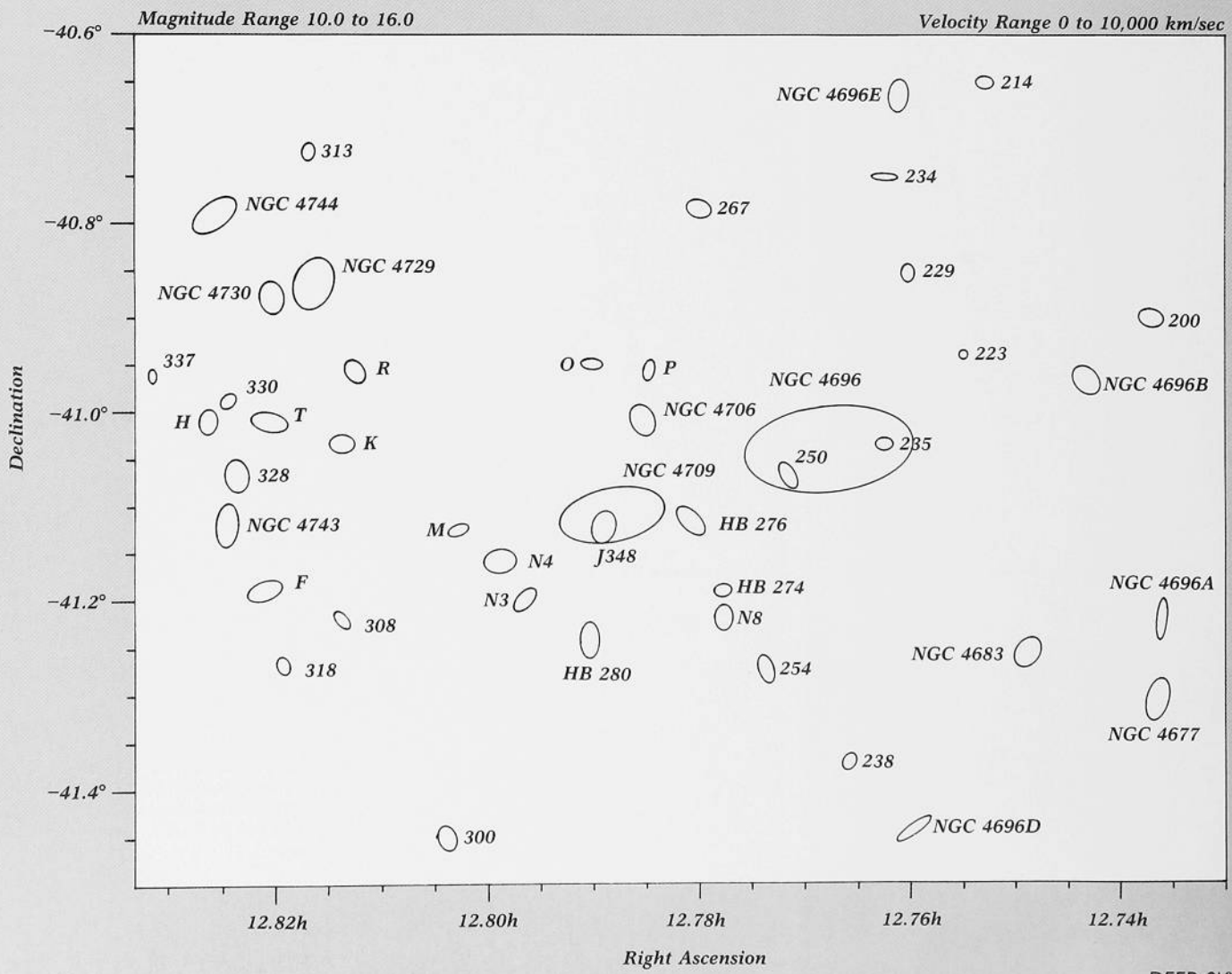
Some 250 galaxies belong to the Centaurus galaxy cluster, a loose assemblage of mostly small ellipticals covering 30° by 20° and centered 9° northwest of Omega Centauri. This piece of plate J4830 from the U.K. Schmidt Telescope shows the central concentration of Centaurus Cluster members. Copyright SRC, Royal Observatory, Edinburgh.



A side-view wedge plot of the Centaurus cluster shows bright members in the cluster's central region. NGC galaxies are plotted as circles and anonymous galaxies as crosses. Diagram by Jeffrey Corder, after R. J. Dickens et al., MNRAS *220:679-711 (1986).*



This edge-on perspective wedge plot shows radial velocities of Centaurus galaxy cluster members versus declination and reveals the cluster's bimodal structure. Diagram by Jeffrey Corder.



The core of the Centaurus galaxy cluster from plate J7749 of the U.K. Schmidt survey. The large elliptical galaxy at right center is NGC 4696, an 11th-magnitude object. To the southeast is the 12th-magnitude elliptical NGC 4709. Copyright SRC, Royal Observatory, Edinburgh.

The Hydra-Centaurus Supercluster Member Galaxy Groups

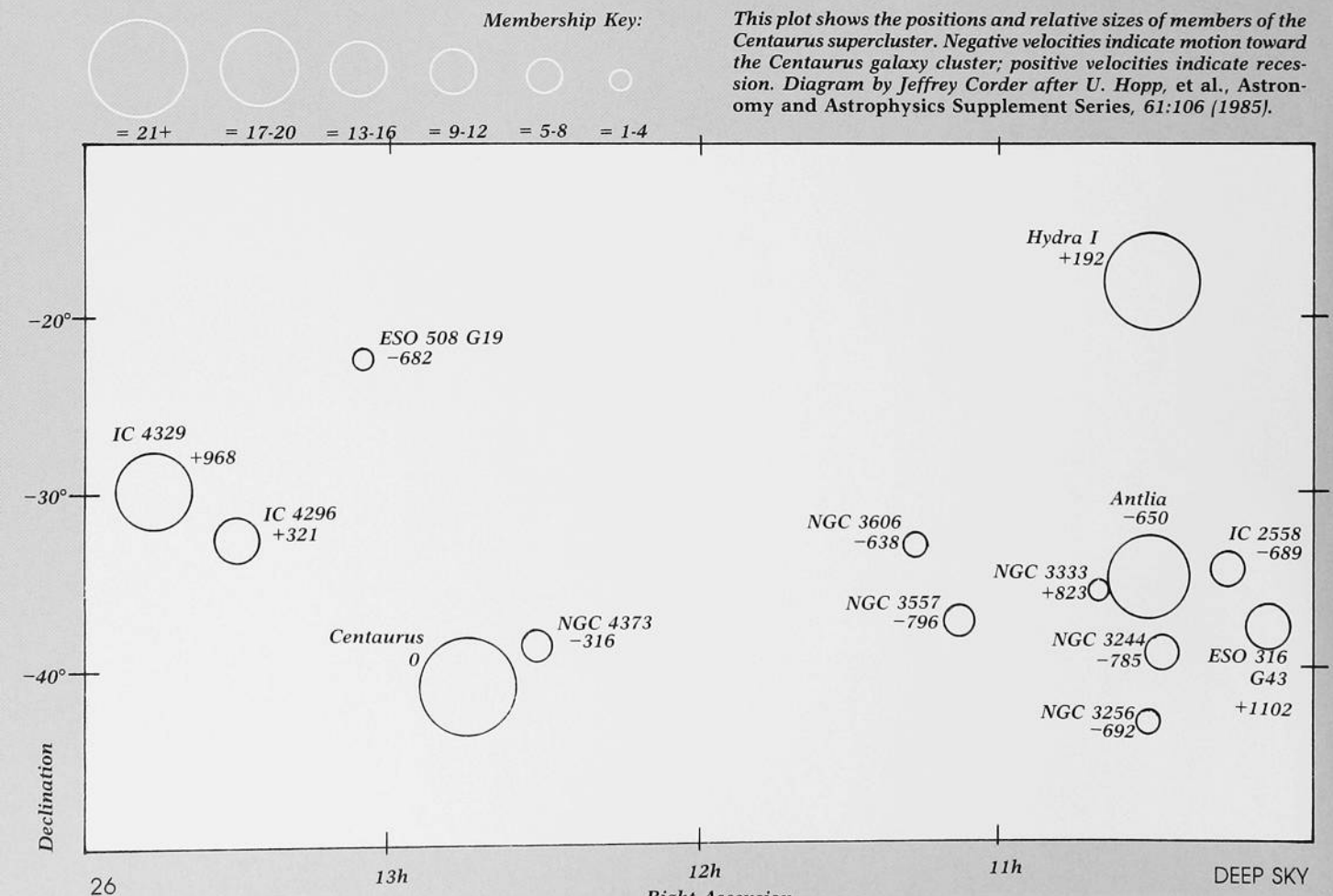
Name	R.A.	Dec.	Velocity	Members
ESO 316-G43	10h08.8m	−38.00°	4612 km s^{-1}	9
IC 2558	10h13.8m	−34.06°	2821	6
NGC 3244	10h23.0m	−39.31°	2725	8
NGC 3256	10h26.7m	−43.57°	2818	4
Antlia	10h28.4m	−34.59°	2860	20
Hydra I	10h34.4m	−27.16°	3702	
NGC 3333	10h38.8m	−36.13°	4333	3
NGC 3557	11h08.1m	−37.04°	2714	5
NGC 3606	11h13.2m	−33.38°	2872	3
NGC 4373	12h26.8m	−39.10°	3194	6
Centaurus	12h46.6m	−41.02°	3510	61
ESO 508-G19	13h06.7m	−23.34°	2828	4
IC 4296	13h31.9m	−33.23°	3831	10
IC 4329	13h46.0m	−30.11°	4478	18

From "The Antlia cluster of galaxies and its environment: The Hydra I-Centaurus supercluster." Hopp, U., and Materne, J. (1985). *AAP Suppl. Ser.*, V61, p104.

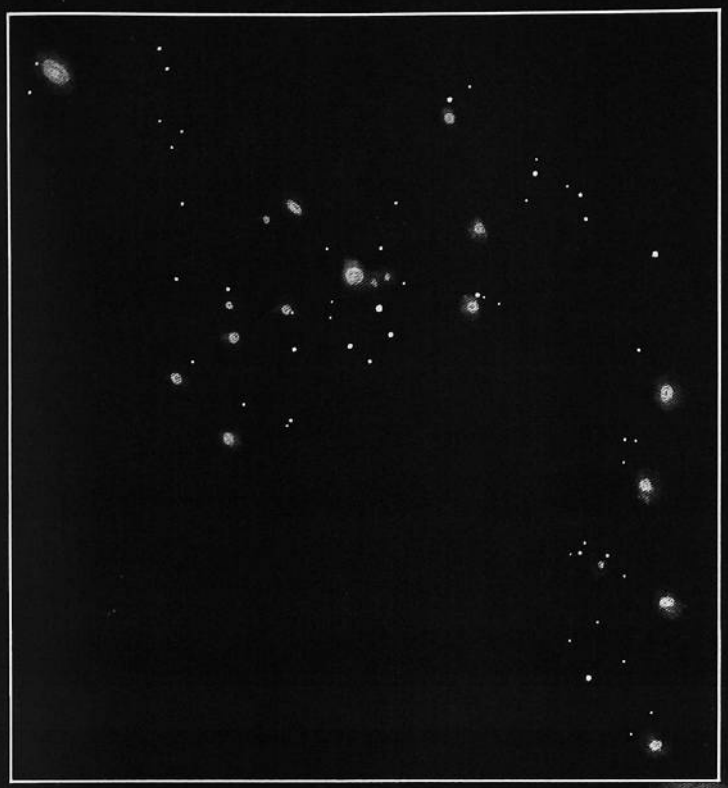
Galaxy Groups Surrounding the Centaurus Cluster

Name	R.A.	Dec.	Velocity	Members
NGC 4373	12h31.m	−39.00°	3081 km/sec	7
NGC 4603	12h39.m	−40.50°	2893	16
NGC 4616	12h42.m	−40.50°	4480	14
NGC 4767	12h50.m	−39.40°	3170	6
NGC 4930	13h00.m	−41.10°	2714	11
ESO 323-G77	13h05.m	−40.00°	4701	5
NGC 5011	13h10.m	−42.55°	2980	11
NGC 5090	13h18.m	−43.40°	3719	5

From "The Centaurus cluster of galaxies — III. Its structure and the distribution of the different galaxy types." Lucey, J. R., Currie, M. J., Dickens, R. J. (1986). *MNRAS*, V222, p433.



This plot shows the positions and relative sizes of members of the Centaurus supercluster. Negative velocities indicate motion toward the Centaurus galaxy cluster; positive velocities indicate recession. Diagram by Jeffrey Corder after U. Hopp,* et al., Astronomy and Astrophysics Supplement Series, *61:106 (1985).



NGC 4672
NGC 4696A
NGC 4677
NGC 4683
NGC 4696
HB 276
NGC 4706
NGC 4709
P
J348
HB 280
O
N3
N4
NGC 4729
F
NGC 4730
NGC 4743
NGC 4744
H
G

The Centaurus galaxy cluster sketched by Jeffrey Corder with a 17.5-inch f/4.5 reflector at 230x.

Inset: The NGC 4696 galaxy group sketched with the same instrument.

Stacked plates from the U.K. Schmidt telescope form this image of the cluster's core. Most of the galaxies are ellipticals and lenticulars. Copyright SRC, Royal Observatory, Edinburgh.

Top inset: A contrast-enhanced image of the cluster's inner core shows faint features including a jet south of NGC 4709. Malcolm Smith made this image with Cerro Tololo's 4-meter reflector.

Below: David Malin of the Anglo-Australian Telescope team used unsharp masking to reveal a dust lane in NGC 4696. The jet south of NGC 4709 is aligned with this dust lane. Photographs courtesy Malcolm Currie, Rutherford Appleton Laboratory.

The Centaurus Galaxy Cluster

No.	NGC, etc.	(1950) R.A.	Dec.	Type	(km/sec) Vel.	ESO	Mag.	Size	Or.
189	4672	12h43.3m	−41.26°	S	3315	G073	13.81		56°
197	4696A	12h44.1m	−41.13°	S	2561	G077	14.25		174°
199	4677	12h44.1m	−41.18°	S0	3081	G078	13.56		165°
205	4696B	12h44.4m	−40.58°	S0	3023	G081	13.38		44°
212	4683	12h44.5m	−41.15°	S0	3580	G083	13.51		132°
228	4696D	12h45.4m	−41.27°	S0	2503	G088	13.57		125°
229		12h45.4m	−40.51°	E	3483	G089	15.05		36°
233	4696E	12h45.4m	−40.40°	S0	1860	G090	14.20		175°
238	J324	12h46.0m	−41.22°	S0	2061		14.94		162°
242	4696	12h46.0m	−41.02°	E	2923	G091	11.02		97°
254		12h46.3m	−41.16°	S0	2861	G096	14.81		22°
263	N8	12h46.4m	−41.13°	S0	4207	G099	14.08		5°
264	HB274	12h46.4m	−41.12°	S0	4745	G100	14.31		89°
267		12h46.5m	−40.47°	S0	1971	G101	14.12		73°
268	HB276	12h46.5m	−41.07°	S0	3651	G102	14.07		45°
275	P	12h47.1m	−40.57°	E	2246		14.56		167°
278	4706	12h47.1m	−41.00°	S0	3708	G001	13.53	1.6′ x 0.6′	33°
282	4709	12h47.2m	−41.07°	E	4519	G003	11.92	2.0′ x 1.8′	102°
284	N2	12h47.2m	−41.08°	E	4793		14.24		166°
286	O	12h47.3m	−40.57°	E	2656		15.13		78°
288	HB280	12h47.3m	−41.15°	S0	2615	G005	13.68	1.4′ x 0.6′	7°
292	N3	12h47.5m	−41.12°	S0	5274	G008	14.28	1.2′ x 0.4′	132°
293	N4	12h48.0m	−41.10°	S0	2334	G009	14.23	1.1′ x 0.5′	84°
298	M	12h48.1m	−41.08°	S0	4636		15.05		107°
300	J328	12h48.1m	−41.27°	E	2462		14.55		37°
306	R	12h48.5m	−40.57°	S	4757	G013	14.70	1.2′ x 0.3′	38°
309	K	12h48.5m	−41.02°	S0	3415		14.76		85°
314	4729	12h49.0m	−40.52°	E	3242	G016	12.98	1.6′ x 1.6′	159°
318	JF17	12h49.1m	−41.16°	S0	3606		14.88		30°
320	4730	12h49.1m	−40.53°	S0	2052	G017	13.53	1.0′ x 1.0′	22°
323	T	12h49.1m	−41.01°	S	4974	G018	14.32	1.7′ x 0.8′	73°
325	F	12h49.2m	−41.11°	S	3801	G019	13.60	1.6′ x 0.7′	106°
328	J355	12h49.3m	−41.04°	S	4953	G020	14.66	1.4′ x 1.4′	8°
331	4743	12h49.3m	−41.07°	S0	2894	G021	13.45	1.6′ x 0.6′	176°
332	4744	12h49.3m	−40.47°	S	3335	G022	13.03	3.0′ x 1.5′	128°
333	H	12h49.4m	−41.01°	S0	4635		14.34		179°
339	G	12h50.0m	−41.04°	S0	4744	G028	13.78	1.8′ x 1.1′	27°
355	A	12h50.4m	−40.56°	E	4293	G034	12.62	2.2′ x 1.1′	165°

Source: "The Centaurus Cluster of Galaxies — I. The Data." R. J. Dickens, *et al.*, *MNRAS*. 1986, v220, pp.679-711.

1. Sizes taken from the ESO/Uppsala catalogue, plate no. 323.
2. Magnitude to 26.5 isophote in V.
3. Orientation measured from north through east.

Additional Cluster Member Parameters

Name	(1975) R.A.	Dec.	Type	Mag.	Incl.	Vel. (km/sec)	Size
NGC 4645 A	12h41.44m	−41°13.24′	S0	13.10	29°	3240	
NGC 4645 B	12h42.09m	−41°13.26′	S0	13.18	157°	2610	
NGC 4645	12h42.48m	−41°37.06′	E5	12.69	52°	2460	
NGC 4681	12h46.05m	−43°12.08′	S	13.80	0°		
NGC 4679	12h46.08m	−39°26.24′	S	13.12	179°		
NGC 4696 C	12h46.42m	−40°40.05′	S	14.30	139°	3760	
NGC 4751	12h51.28m	−42°31.34′	S0	12.48	175°	1920	3.5′ x 1.5′
NGC 4811	12h55.29m	−41°39.49′	S0	13.80	35°	3180	1.2′ x 0.8′
NGC 4812	12h55.29m	−41°40.48′	E/S0	14.30	36°	3400	1.5′ x 0.4′
NGC 4909	13h00.38m	−42°38.13′	S0	12.30	28°	3240	

Sources:

1. Dawe, J. A., *et al.* (1977) *MNRAS*, V178, pp678, 679.
2. Sersic, J. L. (1967) *Z Ap*, VF67, p308.
3. Sandage, A. (1975) *ApJ*, V202, p569.
4. Sandage, A. (1978) *AJ*, V83, p913.
5. Holmberg, E. B., *et al.* (1977) *A&Ap Suppl. Ser.*, V27, p300.
6. Shobbrook, R. R. (1966) *MNRAS*, V131, p356.
7. Dickens, R. J., *et al.* (1986) *MNRAS*, V220, pp697-708.

it is very much elongated almost exactly north-south and small — only 40″ by 25″ in extent. A faint central core is the only other feature visible.

NGC 4696A lies to the north of NGC 4677. The third member of the trio, this active Seyfert galaxy is oriented edge-on. In a 12-inch telescope the galaxy appears extra faint and small, much elongated and thin, and measures about 30″ by 10″. The core is tiny and not very bright.

Southwest of the trio you may spot **NGC 4672**. Also a nearly edge-on spiral, this magnitude 13.8 galaxy looks like a nebulous bar of light 50″ by 20″ across through a 12-inch telescope. The galaxy is oriented nearly northeast-southwest and has a moderately bright center. Nearby are four 13th- to 14th-magnitude stars arranged in a short arc.

Surrounding NGC 4709 are a number of small, very faint anonymous E- and S0-type galaxies. With the exception of **NGC 4706**, all of the galaxies are fainter than magnitude 14.0 and were discovered photographically. NGC 4706 is the brightest of the group at magnitude 13.5 and measures 40″ by 30″ in extent. It is easily visible at 100x in a 12-inch reflector and appears as a compact nebulosity with a very bright core elongated northeast-southwest.

Anonymous **galaxy P** lies just 15′ north of NGC 4709 and is a foreground member of the Centaurus cluster. With a 17.5-inch Dobsonian telescope from a dark site just outside Everglades National Park the magnitude 14.5 elliptical galaxy still appeared very faint. It appears oval in shape, elongated north-south, and 30″ in diameter with a bright center. Its neighbor, anonymous **galaxy O**, is even fainter. Glowing softly at only magnitude 15.1, it is definitely elliptical in shape and measures 35″ by 25″ — little more than a tiny smear of nebulous light.

Between NGC 4709 and NGC 4696 lies a lone galaxy. This is the anonymous S0 galaxy catalogued as **HB 276**. It lies 8′ west of NGC 4709 and is bright enough to be spotted in a 12-inch telescope. My own observing notes with a 17-inch reflector read: "Faint and very small, 45″ by 30″ across, elongated northeast-southwest and contains a bright core. A 15th-magnitude star is just 2′ north."

Just 90″ southeast of NGC 4709 is the 14th-magnitude galaxy **N2**. N2 lies at the background of the cluster. It is a basically featureless and very faint object that measures only 20″ by 15″. On photographs N2 is easily overwhelmed by the nearby 12th-magnitude galaxy NGC 4709.

Starting 5′ southeast of NGC 4709 is an evenly spaced line of three faint S0-type anonymous galaxies. The brightest of the group is **HB 280**, which shines at magnitude 13.7. In a 17-inch telescope it seemed slightly elongated north-south, was 40″ by 35″ across, and faint with a small, bright center. A 14th-magnitude star is situated 40″ southwest of the galaxy.

The magnitude 14.3 galaxy **N3** lies 7′ northeast of HB 280. It was mislabeled as NGC 4729 in the *RNGC*, but NGC 4729 actually lies 30′ to the northeast. N3 is considered a background member of the Centaurus cluster because of its relatively high redshift. Through a telescope N3 is very faint, small and slightly oval, and measures 35″ by 30″. Its neighbor **N4** is equal in every respect — faint, small and slightly oval. N4 can be spotted 40″ north of a 12.5-magnitude star. N4 was also misidentified in the *RNGC* as NGC 4730.

Venturing about 20′ farther east, you will encounter another concentration of Centaurus cluster galaxies. One of the most prominent of these is **NGC 4743**, a magnitude 13.5 S-type galaxy, one of the nearest cluster members. From only a mediocre site on in the rural Punta Gorda, Florida, NGC 4743 was visible in a 12-inch telescope as a faint, small nebulosity oriented almost due north-south. It measures 40″ by 35″ and contains a bright nucleus.

Anonymous spiral **galaxy F** lies 7′ south of NGC 4743. This galaxy shines at magnitude 13.6, so I wonder how visual observers of the late nineteenth century missed it? In a 12-inch telescope it appears faint and diffuse, 40″ in diameter, and elongated east-west.

Seven arcminutes north of NGC 4743 is an 11th-magnitude star that can be used as a guide to locating other cluster members nearby. Anonymous **galaxy H** lies 5′ north- northeast of this star. It appears faint, small, 40″ by 25″ across, and elongated north-south. Ten arcminutes east of the 11th-magnitude star is **galaxy G**, a magnitude 13.8 anonymous system. It appears extra faint, small and elongated, and 45″ by 35″ across. The galaxy has a brighter center and a 15th-magnitude star seemingly attached to its southern end.

Galaxy A lies 25′ northeast of the 11th-magnitude star. At magnitude 12.6 this anonymous galaxy outshines most of the NGC cluster members! Galaxy A is a fairly bright elliptical that appears somewhat diffuse and small. It is elongated north-south, 45″ by 30″ in extent, and has a bright middle.

The 13th-magnitude galaxy **NGC 4729** belongs to a bright trio of NGC galaxies in the northeastern part of the galaxy's cluster central regions about 35′ northeast of NGC 4709. In a 12-inch Newtonian from rural Punta Gorda the galaxy appeared pretty bright and almost round. It is 45″ in diameter and has a bright middle. A 15th-magnitude star is situated 20″ to its north. To the southeast of NGC 4729 lies the very compact S0-type galaxy **NGC 4730**. This 13th-magnitude galaxy visually appears faint and small. This small oval of nebulous light was 35″ in diameter and elongated north-south. Some 8′ northeast of these two galaxies is **NGC 4744**. This object is a highly inclined spiral galaxy. It appears in an almost edge-on aspect. It measures at least 75″ by 45″ in extent, is oriented northwest-southeast, and has a faint middle but a much brighter nucleus. It is situated almost exactly between two 15th-magnitude stars.

The Centaurus galaxy cluster can be a great challenge for telescopic explorers. It contains a wide variety of galaxies of different types and sizes. The cluster abounds in anonymous galaxies, and it is currently the focal point of study for many southern observatories.

Pick a good dark site with a clear view to the south and hunt down some of these remarkable, remote galaxies some night this spring.

Jeff Corder is a frequent contributor to Deep Sky.

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10. "The Great Attractor," News Notes, *Sky & Telescope*, August 1987, 119.
11. "Streams in the Cosmic Flow," News Notes, *Sky & Telescope*, July 1986.

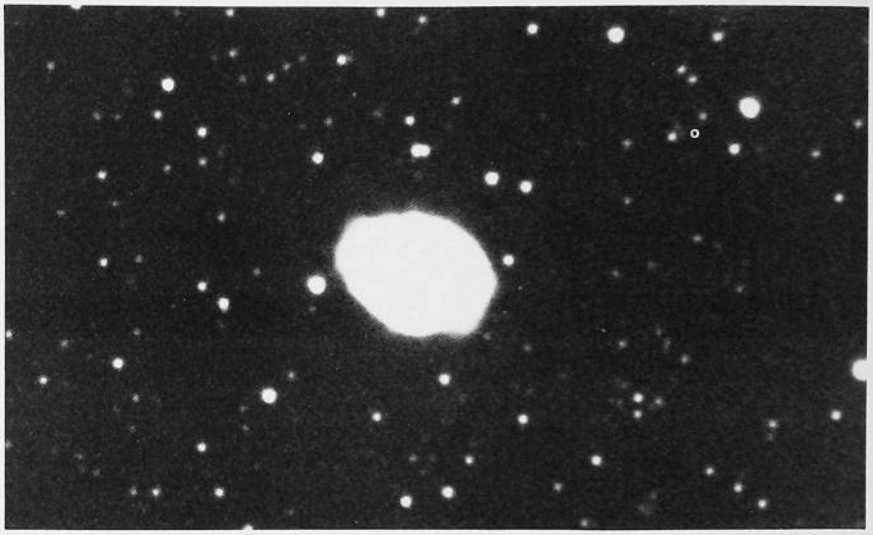
Photo Feature

The Amazing Photography of Martin C. Germano

Rarely do we publish photographs in *Deep Sky* for the sake of publishing photographs. Rather, we try to choose illustrations for articles that show relevant objects or make a point. However, when I opened up the latest package of photographs from California photographer Martin C. Germano, I had to make an exception.

Marty has sent photos to *Deep Sky* and *Deep Sky Monthly* for ten years. He has probably contributed more photos than any other single photographer, and his work is uniformly excellent. After shooting practically everything he could with an 8-inch SCT, Marty has now turned to an 8-inch Newtonian, which he transports to Mount Pinos, north of the Los Angeles area. The results are dramatic, and I think you'll enjoy seeing them.

— *David J. Eicher*



Above right: *The faint barred spiral IC 1296 lies just 2.9′ northwest of the Ring Nebula in Lyra, which appears overexposed. Photographed with an 8-inch f/10 SCT, hypered Tech Pan film, and a 75-minute exposure.*

Right: *This photograph captures structure in the elusive emission nebula NGC 1491 in Perseus and includes a faint outer envelope of nebulosity. Photographed with an 8-inch f/5 Newtonian, hypered Tech Pan film, and a 45-minute exposure.*

Below right: *Seldom does an amateur photograph show crisp details like this shock front in the "Gulf coast" region of the North America Nebula. Photographed with an 8-inch f/5 Newtonian, hypered Tech Pan film, and a 50-minute exposure.*

Opposite page: *The 10th-magnitude elliptical galaxy NGC 404 lies within the same field as Beta Andromedae and is difficult to spot because of the star's glare. However, Germano's photograph shows both objects clearly. Photographed with an 8-inch f/5 Newtonian, hypered Tech Pan, and a 35-minute exposure.*

Inset: *IC 1318A, one of the Gamma Cygni nebulosities, photographed with an 8-inch f/5 Newtonian, hypered Tech Pan film, and a 45-minute exposure.*

Small Scope Showcase

Comet Hunting for Galaxies

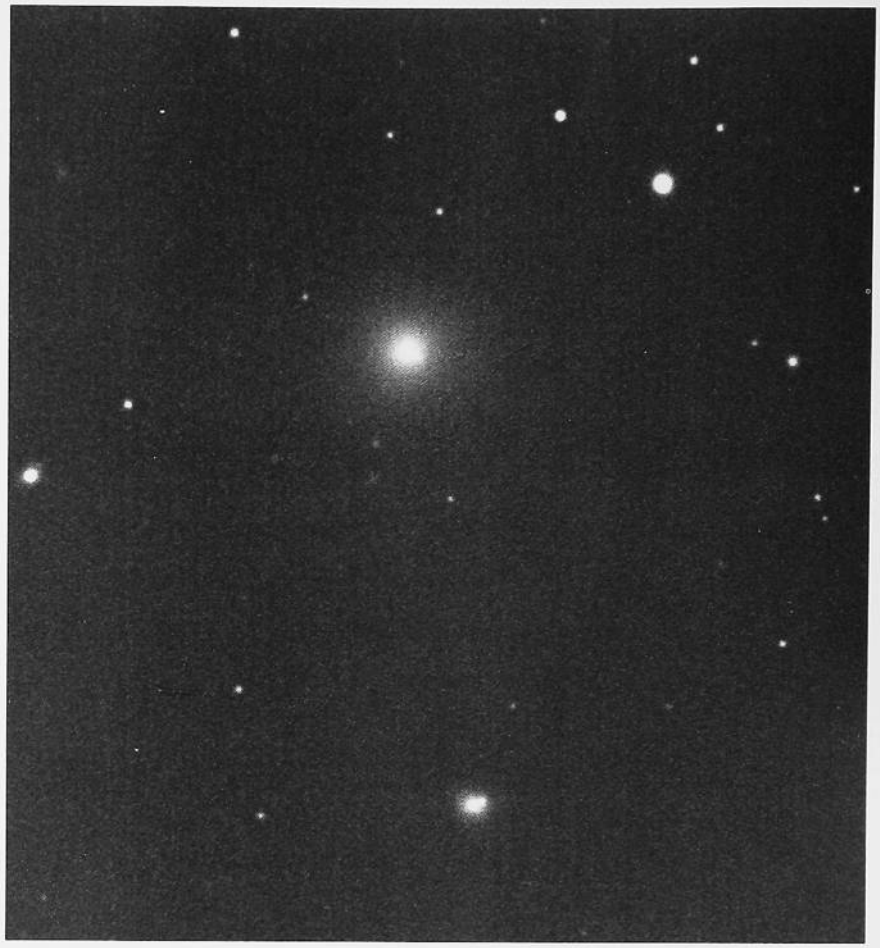
by David H. Levy

Since 1965 I have hunted for comets, and I have not been very successful: I have found only three. However, through all these years my program has offered an exciting introduction to hundreds of galaxies, clusters, and nebulae in a way I would hardly have expected!

Spring is the time when clusters of galaxies are prominent. All the guides tell you to visit **M104,** the beautiful Sombrero Galaxy, appropriately located at the southern end of the "Realm of Galaxies" in Coma Berenices and Virgo and to have a look at the huge elliptical galaxy M87 in the same "supercluster." This time let's try something different. Let the sky show you its wonders in its own way. Hunt for comets and discover galaxies.

Frankly, in this case your aim should not be to discover comets, for the sky's galaxy-laden regions are a frustrating place to search for comets which resemble galaxies in some ways. That's not my point. The hunt itself, which allows the sky to show you what it chooses on its own terms, is the approach you should take. Try this and you will find something quite unexpected. Instead of looking at a single galaxy, you will slowly begin to understand the nature of a whole cluster of galaxies. Begin with bright Arcturus, truly a gateway to the Coma Virgo supercluster, and hunt toward the south and east along strips of sky. Move your telescope in a pattern, up a strip of sky, then down an adjacent strip. Pretty soon you will start to learn something about the distribution of galaxies in the sky. The boundary between sky with occasional galaxy and sky studded with many galaxies is quite sharp; in fact two or three fields make quite a difference. And what a border it is! Instead of trying to identify a galaxy by the unique pattern of stars around it, your field may have as many galaxies in it as stars.

Take, for example, the field of **M84** and **M86.** Fabulous! It looks like the constellation Sagitta, all in the low-power field of view, except the "stars" that form the arrow pattern are all galaxies. Faint NGCs 4438 and 4435 form the arrow's back, M86 is in the middle, and M84 is the point. With larger telescopes more galaxies come into view: I have seen seven in that one field with



Top: M87, the largest object in the Virgo Cluster, is a supermassive elliptical galaxy. A bright comet might look exactly like M87 in the eyepiece.

Above: Conspicuous at the center of the Virgo cluster of galaxies, M84 (right) and M86 are bright ellipticals strongly resembling comets. Photos by Martin C. Germano.

Above right: Rarely would a comet lie next to another patch of nebulosity, as is the case with M60 (left) and its fainter companion NGC 4647. But without checking a star atlas, you couldn't be sure.

my 16-inch reflector. If your sweep carries you farther south and east, you should then meet mighty **M87** with its trillions of stars, one of the largest galaxies detected anywhere. The sweep continues with **M58, M59,** and **M60.** Later you may even sweep far enough to pick up **M64,** the Blackeye Galaxy with a huge dust lane that makes it look like something out of a western movie set.

Your sweep may eventually carry you in other directions, perhaps back through Coma Berenices where **NGC 4565** shines like a pencil with an oversized central bulge. One of the finest examples of an "edge-on" spiral, this galaxy resembles what our Milky Way might look like were we to see it from a distant point but still on its plane.

Now let's try a different sweep — same southwesterly direction but a new starting point in the handle of the Big Dipper. As you travel through Ursa Major, you will again see many galaxies, but this time they will appear different — perhaps less distinct than their Virgo cousins. The Ursa Major galaxies tend to be more diffuse, less structured. For a comet hunter, this is an important distinction; to me, the Coma-Virgo galaxies look like galaxies, but many of the Ursa Major galaxies have the diffuseness of comets. There are exceptions, of course: **M63** in Canes Venatici is large and noticeably elongated, and **M51,** the Whirlpool Galaxy, is really a stunning sight with arms that are visible through a 6-inch scope.

If you search back through northern Ursa Major you may encounter mighty **M81** and **M82,** a fine pair of galaxies. M82 has a mottled look, almost tortured; it is a galaxy that must have suffered some disruption to show such an unusual appearance. These two galaxies prove that magnitude alone does not decide how easy a galaxy will be to see. There are galaxies brighter than M81 and M82, but these two are also quite condensed: their brightness is spread out over a small area and thus should be easy even from a city sky.

What size telescope should you have for these sweeps? The answer may surprise you. The size of your telescope matters less than the telescope's focal length and the condition of the sky. The delicate, diffuse patches of nebulosity require dark sky backgrounds to show themselves clearly. A telescope with a narrow field of view (less than 1/2°) will simply not show enough sky to make the galaxies stand out. Moreover, the best telescope in the world will show virtually nothing of the faint Ursa Major galaxies if it is under a city sky. I have enjoyed this sweep with a 6-inch f/4, an 8-inch f/7, and a 16-inch f/5; they all show different things from different perspectives, but all the views are beautiful.

One telescope I do not recommend for this sweep is a long-focus Schmidt-Cassegrain telescope. The narrow fields of these scopes mean the chances of picking up an interesting galaxy are not as good as they would be with a fast Newtonian or a refractor. The short-focus Newtonians work like fishnets, and while the galaxy you catch might appear near the edge of a field, it would escape completely the narrow field of the SCT. If all you have is a longer focus telescope, you can still enjoy finding and observing these galaxies the traditional way.

With my 16-inch scope I have swept up fainter clusters of galaxies. One group begins south of M42 in Orion; its best is in Lepus. For a region so close to the Milky Way, this area is filled with faint galaxies. Hydra has a massive group of faint, diffuse patches that all look like 11th- and 12th-magnitude comets, just a bit too faint to appear in the smaller telescopes. Curiously, these galaxies tend, on the whole, to be less diffuse than the Ursa Major set, even though they are much fainter.

From all this sweeping, you can clearly see that the Coma-Virgo "Realm of the Galaxies" is a misnomer. The supercluster is just one kingdom among several. As you move through the sky, you'll certainly want to stop and identify each galaxy you see, and thus your journey will take many clear nights. A closing thought . . . imagine how you would feel if the fuzzy you see is not a galaxy but a slowly moving, undiscovered comet?

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Double Stars

Δm

by Brian Skiff

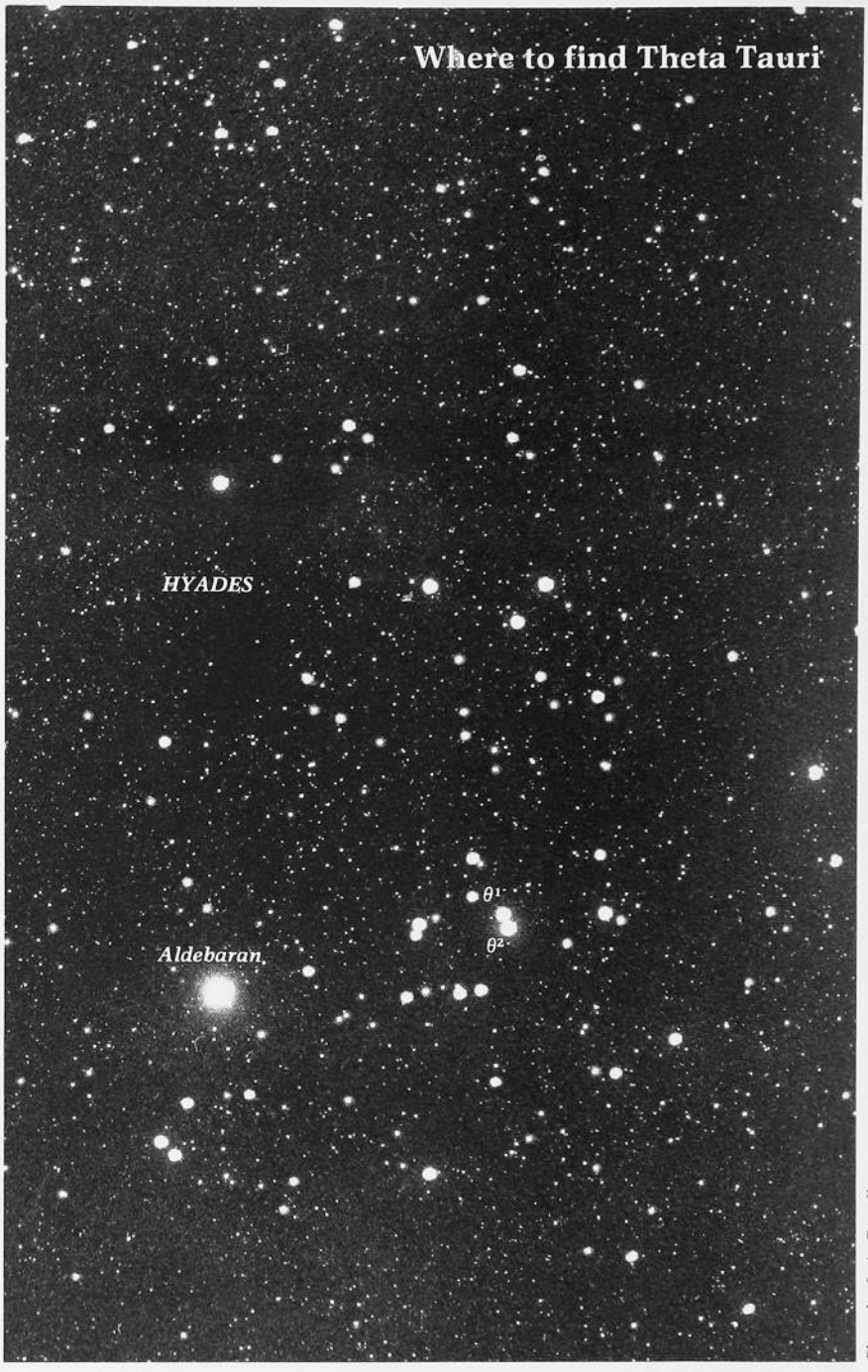

Photo by J. A. Farrell

One of the first things I noticed when I started viewing double stars was that catalogued magnitude differences, Δm, sometimes did not match the view through the telescope. Pairs listed with equal magnitudes were obviously not equal; others with large catalogued differences were more nearly equal than the numbers suggested.

The 1984 *Washington Visual Double Star Catalogue (WDS)*, maintained by the U.S. Naval Observatory, is the primary source for double star data. Although thousands of errors were corrected from the 1961 Lick Observatory *Index of Double Stars (IDS)*, one area not addressed because of lack of information was the heterogeneous magnitude system in the catalogue. Most of the brighter stars are listed in some regular star catalogue, so magnitudes are usually quoted from them (in practice, this meant the 1920s-vintage Henry Draper catalogues). But for the main stars fainter then magnitude 9 or so the only recourse was to magnitudes given by the discoverer or later observers. As many of these worked before the present magnitude scale was established, the values are sometimes way off. It has been found that *WDS* magnitudes are on average about 0.75 magnitude too bright below magnitude 9 or 10, and there is much scatter.

Historically observers have paid more attention to Δm, the difference in magnitude between components, rather than magnitudes on an absolute scale. Not only do these tend to be more consistent, but they help explain why the raw magnitudes themselves are poor. Yet there still seem to be problems. In a very few cases, variations in Δm among different observers is explained by real variability in the component stars; new variable doubles have been found by doing photometry on pairs that have discordant Δms.

How do you estimate Δm by eye anyway? The obvious answer is "experience." One gains it by viewing many doubles of different total brightnesses, colors, and separations where Δm is well established. Eventually such appearance is a function of Δm.

Rather then checking specially selected doubles, I have made a list of naked-eye stars lying fairly close together to serve as practice targets. These can be viewed casually on any night with the aim of getting your eye accustomed to what different Δms look like.

Coordinates are given in the table for the brighter member of the pair. Because few are well-known stars, you'll probably have to look these up on your favorite star chart. By checking several during a viewing session, it is easy to compare and contrast their appearances. The V magnitudes come from the Yale *Bright Star Catalogue* and are listed along with ΔV to a hundredth of a magnitude. For practical purposes you should round these to the nearest tenth. Many of the stars are proper telescopic doubles; while you're at it, check them out at high power while you gauge them at zero power.

The list concentrates on pairs with Δm around a magnitude or less —where brightness differences are most subtle. Some of the stars are a little on the faint side, so urban skygazers may need binoculars. The selection is more or less random, merely a collection of wide naked-eye "pairs" that have caught my

eye over the years. You may want to append the list to other lists. Most of the far southern targets were selected by "extrapolation" of their appearance on small-scale atlases compared to known northern pairs. I would appreciate it if a Southern Hemisphere observer could verify that my selections are useful. In any case I avoided stars known to be large-amplitude variables, although a few with ranges of only a few hundredths of a magnitude were retained.

The apparent Δm seems to depend a lot on the overall brightness and separation. For instance, how do Castor and Pollux compare to theta[1,2] Tauri in the Hyades? The latter are very much closer together and fainter: to me they seem much more nearly equal in brightness even though their ΔV (0.44) is the same as for Castor and Pollux.

If you've never paid much attention to small brightness differences, try to discern a difference between psi[1] and psi[2] Aquarii (ΔV=0.18) or xi[1] and xi[2] Canis Majoris (ΔV=0.21). If the difference is not obvious (albeit small), does continued practice over several months or from one year to the next help?

Frankly, I'm not sure this method will work in helping to estimate Δms accurately at the eyepiece. Real doubles are generally much closer in apparent separation, and at high powers the structure of the diffraction image puts a new variable into the game. Even so, I've found that just spotting these stars has made me pay more attention to the sky.

A way to test your skill is to estimate Δm for an "unknown" identifiable pair and then look them up in a catalogue that lists V magnitudes. This turned up a surprise once. I estimated alpha and beta Aquarii to have a Δm of about 0.3 during the summer of 1987 (beta Aquarii is brighter). Their magnitudes in the *YBS* are V=2.96 and 2.91, respectively. Uh-oh. However, both stars are G-type supergiants, so either or both are likely to be variable — yet neither is even suspected to be, probably for lack of observations.

The wide pair 65 Piscium (=ADS 683, featured in the Fall 1987 issue) is catalogued as having equally bright components. When I observed it, the southeastern component seemed very slightly fainter. As an experiment I tried to discern a difference with my head rotated 180° — I got the reverse impression, so, yes, I'll verify they're equal.

Another time I'll discuss methods of determining precise magnitudes (and colors) for double stars using photoelectric photometry. Several hundred pairs have been measured this way during the last twenty years, including some of the most interesting systems. This is nevertheless a tiny fraction of the 80,000 reported doubles, so much work remains to be done.

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Some Bright ΔM Check Stars

Pair	R.A. (2000)	Dec.	V	ΔV	Remarks
beta[1,2] Tuc	0h31.5m	−62°58′	3.70	1.39	
beta[3] Tuc			5.09		
gamma Tri	2h17.3m	+33°51′	4.01	0.86	
delta Tri			4.87		
7 Tri			5.28	1.27	ΔM for gamma/7 Tri
omicron Tau	3h24.8m	+9°02′	3.60	0.14	omicron Tau is a suspected variable
xi Tau			3.74		
s=5 Tau	3h30.9m	+12°56′	4.11	1.03	
f=4 Tau			5.14		
theta[2] Tau	4h28.7m	+15°52′	3.40	0.44	in Hyades
theta[1] Tau			3.84		
sigma[1] Tau	4h39.3m	+15°55′	4.69	0.38	in Hyades
sigma[2] Tau			5.07		
xi[1] CMa	6h31.9m	−23°25′	4.33	0.21	
xi[2] CMa			4.54		
beta Gem	7h45.3m	+28°02′	1.14	0.44	Pollux and Castor
alpha Gem			1.58		
alpha Cha	8h18.5m	−76°55′	4.01	0.86	
theta Cha			4.35		
iota UMa	8h59.2m	+48°03′	3.14	0.46	
kappa UMa			3.60		
gamma Leo	10h20.0m	+19°51′	1.90	2.89	
40 Leo			4.79		
lambda UMa	10h22.3m	+41°30′	3.05	0.40	
mu UMa			3.45		
delta Crv	12h29.9m	−16°31′	2.95	1.36	
eta Crv			4.31		
epsilon UMa	12h54.0m	+55°58′	1.77	3.16	
78 UMa			4.93		
zeta UMa	13h23.9m	+54°55′	2.06	1.95	Mizar and Alcor
80=g UMa			4.01		
rho Boo	14h31.8m	+30°22′	3.58	0.88	
sigma Boo			4.46		
alpha Cen	14h39.6m	−60°50′	−0.29	0.90	
beta Cen			0.61		
alpha[1] Lib	14h50.9m	−16°03′	2.75	2.40	a difficult naked-eye object
alpha[2] Lib			5.15		
alpha Ser	15h44.3m	+6°26′	2.65	1.78	
lambda Ser			4.43		
epsilon Ser			3.71	1.06	ΔM for alpha/epsilon Ser
omega[1] Sco	16h06.8m	−20°40′	3.96	0.36	
omega[2] Sco			4.32		
beta Ara	17h25.3m	−55°32′	2.85	0.49	both probably slightly variable; large color difference (ΔB−V)=1.6!
gamma Ara			3.34		
lambda Sco	17h33.6m	−37°06′	1.63	1.06	"Stinger" stars
upsilon Sco			2.69		
epsilon[2] Lyr	18h44.3m	+39°40′	4.61	0.08	
epsilon[1] Lyr			4.69		
beta[1] Sgr	19h22.6m	−44°28′	4.01	0.28	
beta[2] Sgr			4.29		
alpha Sge	19h40.1m	+18°01′	4.37	0.00	
beta Sge			4.37		
alpha[2] Cap	20h18.1m	−12°33′	3.57	0.67	
alpha[1] Cap			4.24		
beta Del	20h37.5m	+14°36′	3.63	1.05	zeta Del is a suspected variable
zeta Del			4.68		
psi[1] Aqr	23h15.9m	−9°05′	4.21	0.18	
psi[2] Aqr			4.39		
psi[3] Aqr			4.98	0.77	ΔM for psi1/psi3 Aqr

Variable Stars

What's in a Name?

by David H. Levy

How do we look at the naming of variables, a subject that transcends time of discovery, place in the sky, and type of variation?

We can start with time of discovery, the way Father Argelander did when he devised a scheme he thought would take into account all the variables likely to be found in any constellation. This prominent early variable star observer proposed a simple idea that began with an upper case R, like R Leonis, and continued with S, T, until Z. In those early days it was almost heresy to imagine more than nine variable stars in a single constellation. Since Bayer had already assigned lower case letters a to q (like g Herculis) for stars in his 1603 catalogue, Argelander felt that beginning his variable naming scheme with R would avoid confusion.

Argelander's method could not handle the increasing numbers of variables, and thus his nine letters were quickly exhausted, so the system went to RR, RS to AZ, SS to SZ, and so forth. When even that turned out to be insufficient, variables were assigned AA, AB, AC to AZ, BB, BC, and so on. After QZ the system was given up, and more recently the system simply turned from letters to numbers from V335.

These names relate to place in the sky, our second standard for naming variables. They are attached to stars in the order they are discovered in a constellation, regardless of what type star they are. R Leonis, for example, is a long-period variable in the constellation of Leo the Lion. S Leonis is a long-period-type star, but X Leonis is not. A dwarf nova like SS Cygni but much fainter, X Leonis erupts from 15th magnitude to 12th magnitude in a few hours every few months.

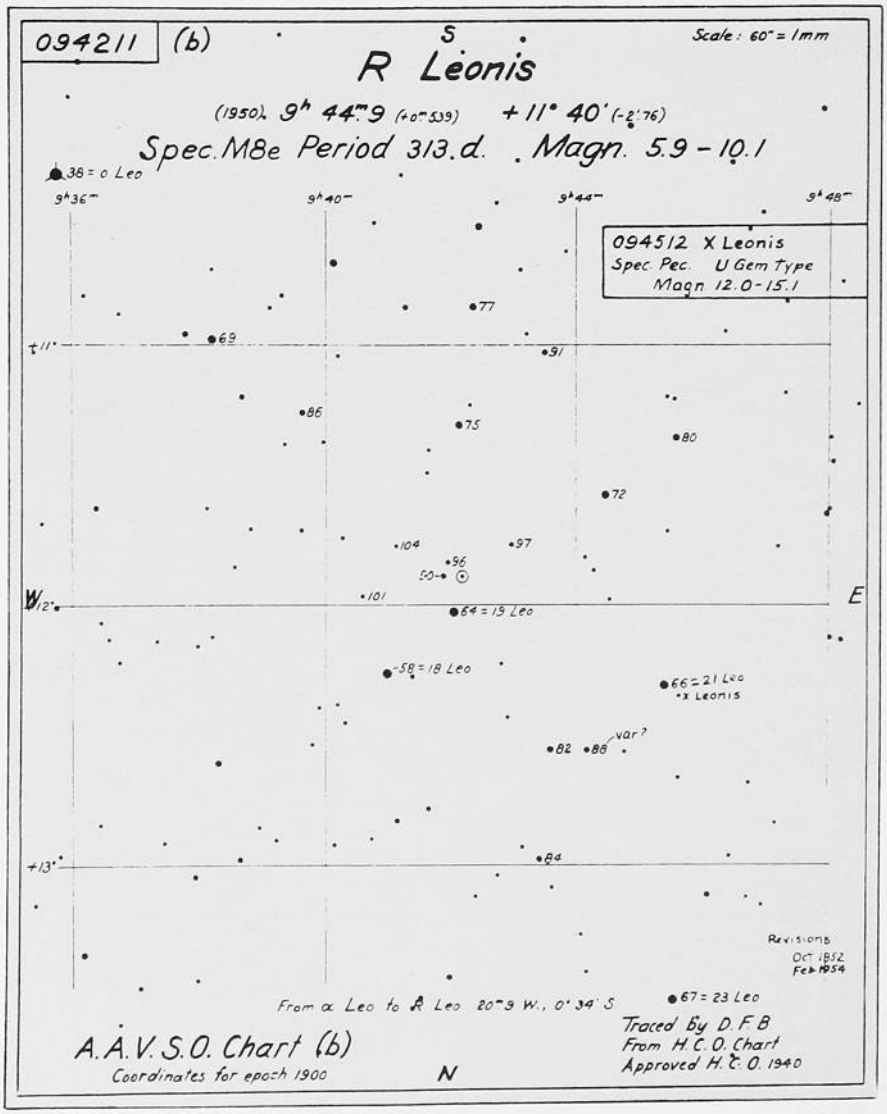
If we want a system that considers place only, why not use the "Harvard Designation," which uses right ascension in hours and minutes for the first four figures, and declination in degrees for the last two figures. In this approach 213843 refers to the 21h38m right ascension and the 43° declination of SS Cygni, and 0530-05 considers the position, including south declination, of T Orionis, a variable in the Orion Nebula. Unfortunately, when this system was begun the epoch was 1900, and thus none of the designations is accurate for finding stars in our 1950 or 2000 epochs. While the Argelander system pays attention to discovery, the Harvard scheme uses positions, and both systems ignoring the type of variation.

But what about type of variation? Take 094512 X Leonis, a faint dwarf nova in Leo. It is so close to brighter 094211 R Leonis that it shares the same AAVSO chart. Close to R in both systems of nomenclature, in type it has absolutely nothing to do with R, a classic Mira-type star with a range of 5.8 to 10.0. X Leonis ranges from its habitual minimum of 15.5 to a maximum of 11.5. Although outbursts supposedly take place every three weeks, faintness means these events are poorly observed. Why not try to change that?

If you have a large telescope, you can monitor the outbursts of X Leonis, even though you may not pick up the star at its faint minimum. If the faintest star you see in your field is 12.5, all you do is record "12.5," which means you did not see X Leonis but that the faintest star you did see was about 12.5 magnitude. Thus, if you use an 8-inch reflector, X Leonis may be for you.

Although some types of variables like dwarf novae are catalogued together by type, there is no real procedure for naming all the variables by type. And what types! We have the eclipsing binaries like 093126 Y Leonis, in which apparent variation is caused by one star passing in front of another. We have symbiotic stars where variation of one type is superimposed upon another. 155526 T Coronae Borealis is such a star. It varies slightly around magnitude

Telescopic Finder Chart for R Leonis



10.2 and thus can be followed easily. However, in 1866 and again in 1946 it behaved in a completely different manner, erupting to 2nd magnitude, a dwarf nova. A "flare star" like UV Ceti can erupt by five magnitudes in a few minutes or even seconds. These are intrinsically small stars, so we know only of those within a few parsecs of our neighborhood.

While symbiotic and flare stars are far from regular, we also have the Cepheids, which are very regular. Delta Cephei, the type star of this class, is visible in the northwest on spring evenings.

Is naming variables any more complex than say, naming comets, which are named first after their discoverers; second, in order of discovery; and third, in order of passage round the Sun? Or how about an extreme case, the naming of cats? Our procedures for naming all three are cumbersome, but they work, and they last. Years ago the poet T. S. Eliot wrote a delightful piece called "Old Possum's Book of Practical Cats," in which he opined about how "The naming of cats is a difficult matter." Thinking that the naming of comets (another interest of mine) was comparable to naming cats, I wrote a variation about the naming of those fuzzy solar system objects last year. Now taking off from the original cat poem and the comet copy, Steve Edberg, a well-known astronomer at California's Jet Propulsion Laboratory, introduces a third poem lamenting the complexity of naming variable stars.

The Naming of Variables

by Stephen J. Edberg

(with apologies to T. S. Eliot)

The naming of variables is a difficult matter,
It isn't just one of your holiday games;
You may think at first I'm mad as a hatter
When I tell you a variable has THREE DIFFERENT NAMES.
First of all, there's the name that the family uses daily,
Such as Eclipse, Symbiotic, Cepheid, or Flare,
Such as U Gem or R Cor Bor, Z Cam, T Tauri —
All of them sensible everyday names.
There are fancier names if you think they sound sweeter,
Some for the gentleman, some for the dames:
Such as Omicron Ceti, V Canum Venaticorum,
RU Lupi, UZ Serpentis, T Piscum,
T Coronae Australis, Beta Persei —
But all of them sensible everyday names.
But I tell you, a variable needs a name that's particular,
A name that's peculiar, and more dignified,
Else how can he keep on his light variation,
Or spread out debris clouds, or cherish his pride?
Of names of this kind, I can give you a score.
UV Ceti, SS Cygni, SU Tauri and such,
Or T Pyxidis, R Bootis, S Persei — there's more —
Names that never belong to more than one star.
But above and beyond there's still one name left over,
And that is the name that at first you can't guess;
The name that no human research can discover —
Until long after the variable's brightened and faded,
Like Nova Cygni '75
But the VARIABLE HIMSELF KNOWS, and won't now confess.
When you notice a star in profound meditation,
The reason, I tell you, is always the same:
His mind is engaged in rapt contemplation
Of the thought, of the thought, of the thought of his name:
His rotational, orbital, nuclear reactional,
Deep and inscrutable singular Name.

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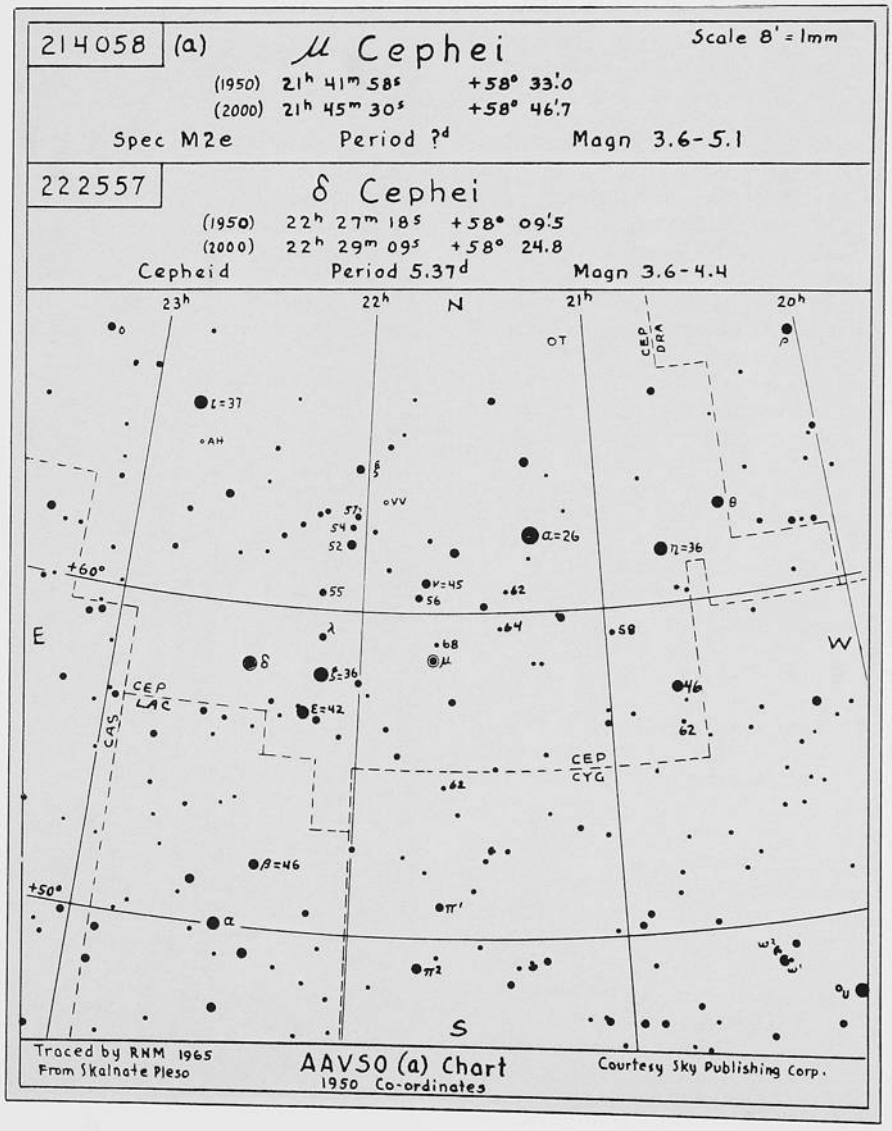
Binocular Finder Chart for Delta Cephei



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Scanning the Literature

December 1987-January 1988

by Brian Skiff

A flood of publications about the Large Magellanic Cloud supernova 1987A has discussed — maybe even over-discussed — every aspect of that event across the entire electromagnetic spectrum. Among the basic data on the explosion is good ol' broadband photometry, which is being done at several Southern Hemisphere observatories. The group of observers handling this at CTIO has published its results for the first six months ("SN1987A in the LMC: UBVRI Photometry at Cerro Tololo," Mario Hamuy *et al.*, *Astronomical Journal [AJ]* **95**:63, January 1988).

All the photometry was done with the 16-inch Cassegrain telescope at the observatory. However, because photomultiplier tubes are so sensitive to light, the telescopes were stopped down using a mask with twenty-six one-inch holes in it. At maximum it was necessary to close all but four of the openings to prevent damage to the tubes!

Besides a table of all the data, the paper includes magnitude and color curves and a discussion of the bolometric (or total) flux of the supernova. As the eruption evolved, greater and lesser amounts of energy were emitted at various wavelengths compared to the visual output. The combined energy of all wavelengths declined rapidly in the first week because of the rapid cooling of the expanding shell; the brightness in the ultraviolet shifted toward the infrared. The flux in all colors then rose to a peak at day ninety (about May 22, 1987) before starting a steady decline of about 1 percent per day that persists now nearly a year after the eruption. The peak V magnitude according to the CTIO measures was 2.98.

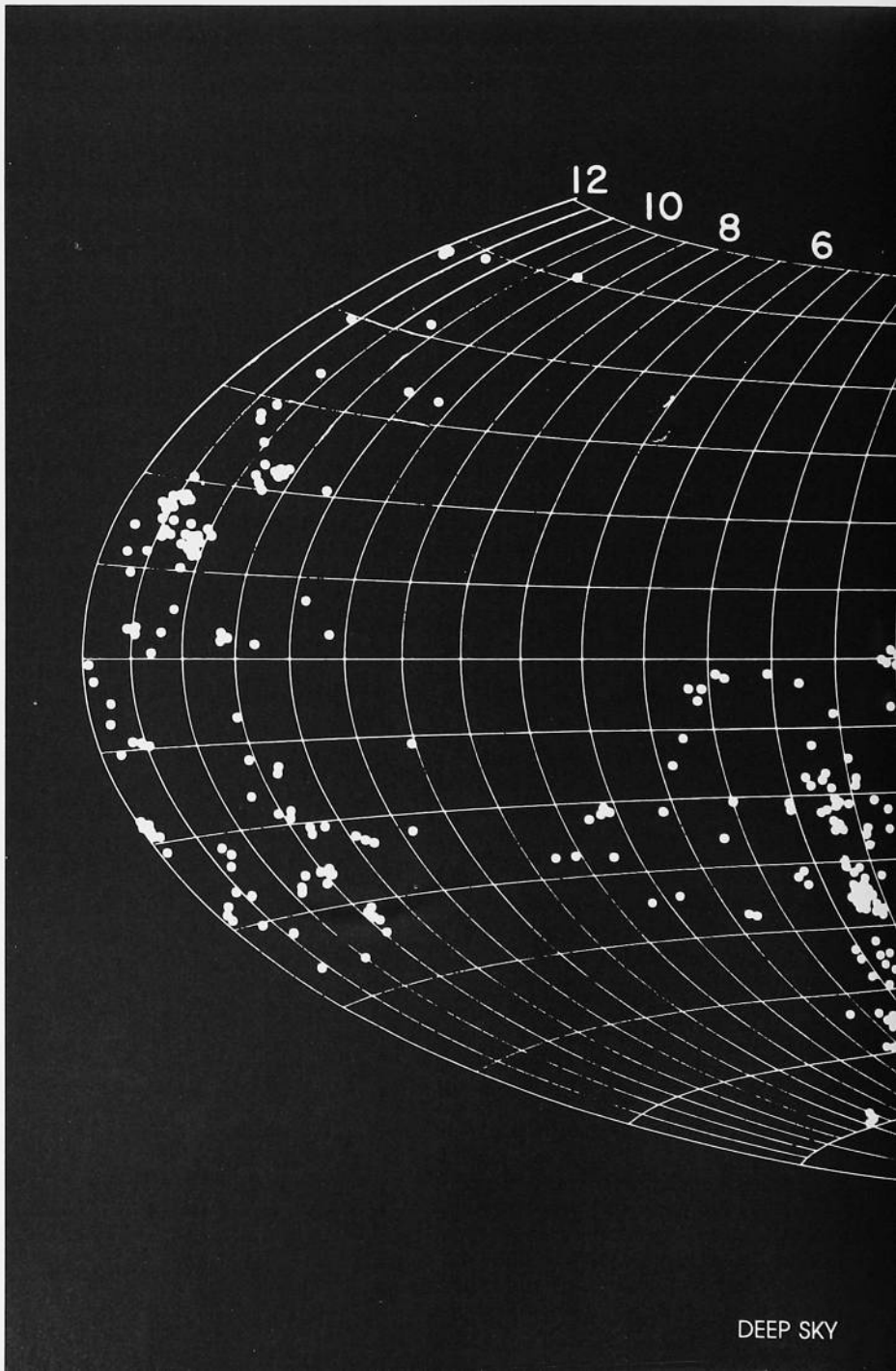
Thanks in part to the excitement over the LMC supernova, more amateurs have begun to search for supernovae. Events bright enough to be found visually with moderate aperture are rarer than comets, so only the most dedicated amateurs find them. Persistence pays off, however: at the end of 1987 Reverend Bob Evans discovered his umpteenth supernova, this one in NGC 7606. Where were the automated search teams?

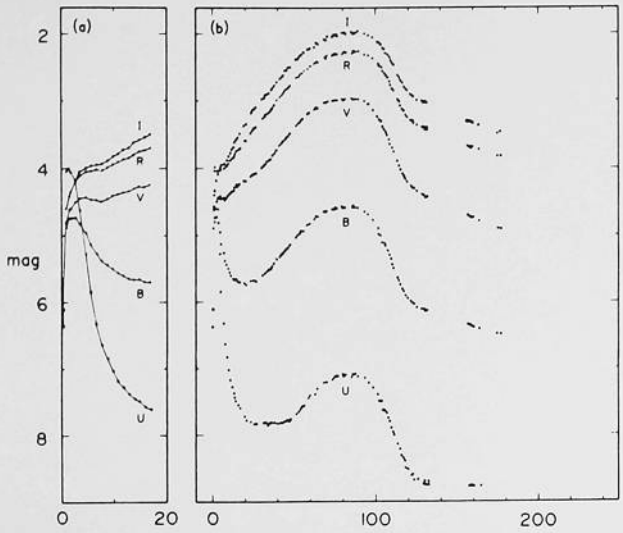
"Rev Ev" (as he is called) is co-author of an analysis of his work ("The Supernova Rate in Shapley-Ames Galaxies,"

Right: Mario Hamuy and colleagues at Cerro Tololo Interamerican Observatory published this light curve for supernova 1987A in the January 1, 1988, edition of the Astronomical Journal. *Given are* UBV $(RI)_{KC}$ *curves for the first six months following the supernova's eruption. The energy given off by the supernova peaked about ninety days after the supernova exploded.*

Far right: How does an enterprising astronomer calculate the diameter of an open star cluster? Get a copy of the POSS *blue plate and count the stars! That's what Peter J. T. Leonard did, and he found that the membership of NGC 2420 merged into the background at a diameter of 40 arcminutes. From Leonard's paper, "Star Counts in the Open Cluster NGC 2420" in the January 1, 1988,* Astronomical Journal.

Below: This diagram shows the distribution of Shapley-Ames galaxies regularly visited by Reverend Robert Evans in his supernova search. Evans is the most successful supernova hunter in history. From "The Supernova Rate in Shapley-Ames Galaxies," Astrophysical Journal, *December 1, 1987.*

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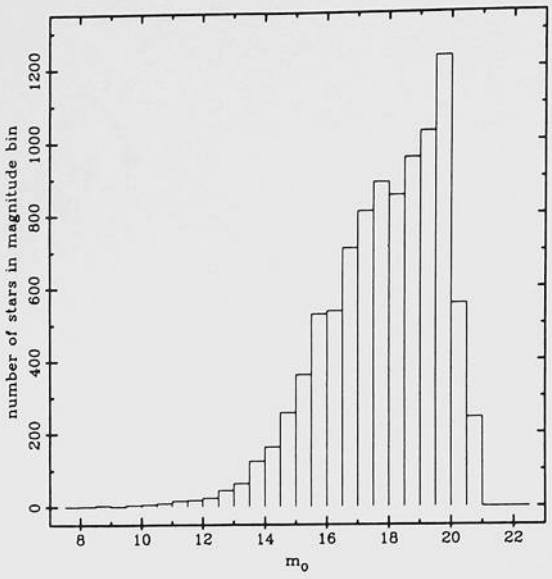
number of stars in magnitude bin
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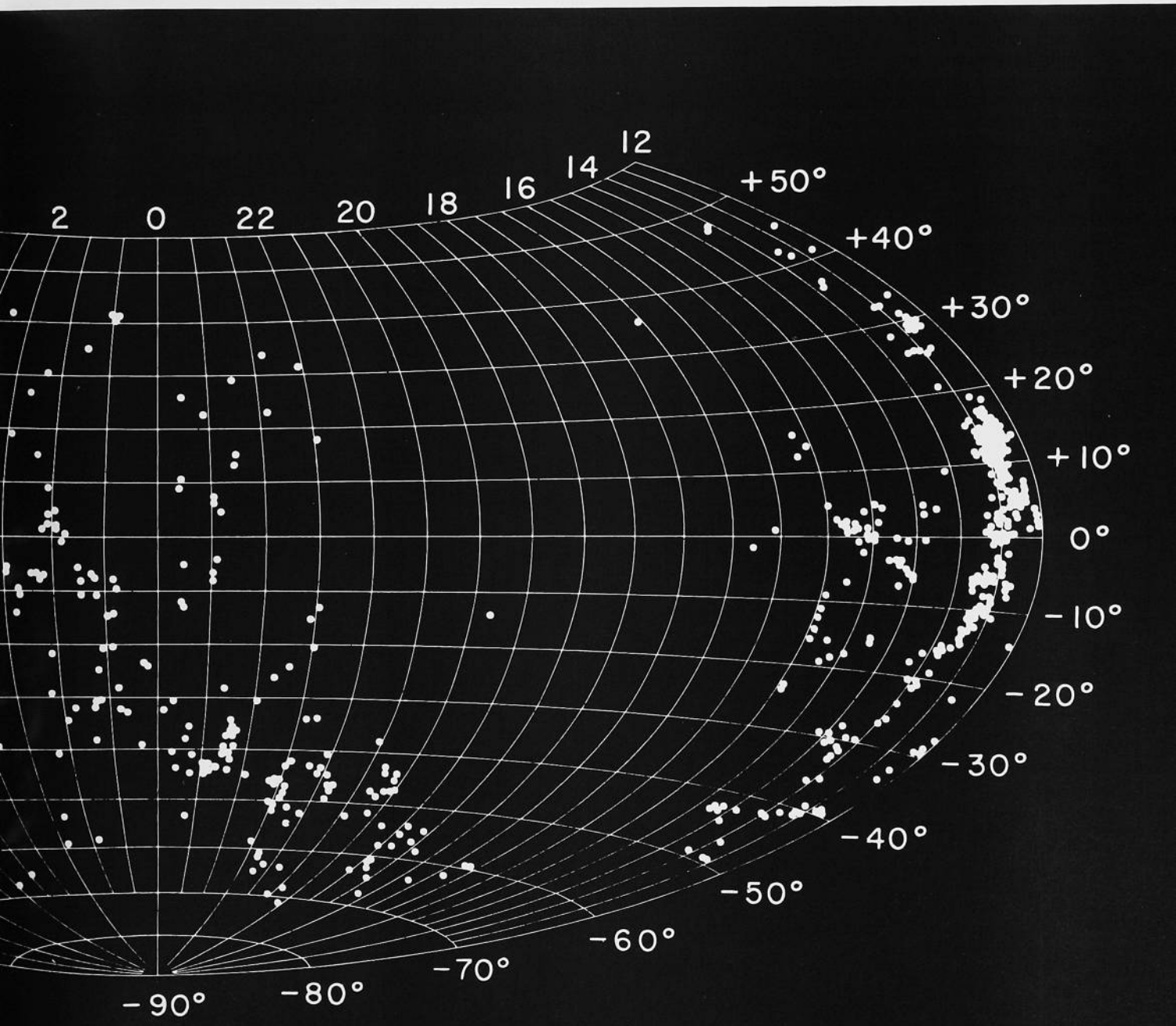
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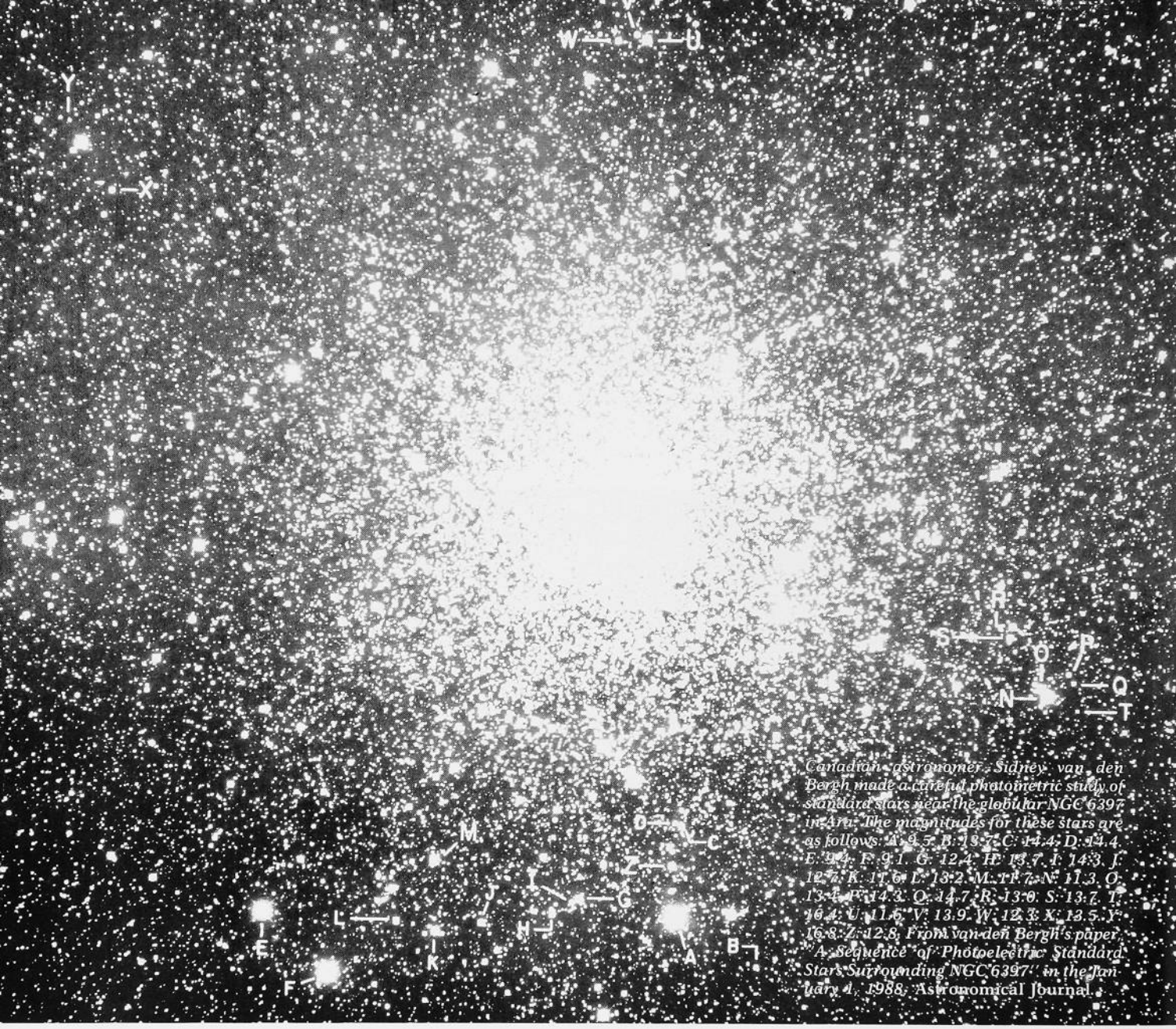
-80°
-90°



Canadian astronomer Sidney van den Bergh made a careful photometric study of standard stars near the globular NGC 6397 in Ara. The magnitudes for these stars are as follows: A: 9.5, B: 13.7, C: 14.4, D: 14.4, E: 9.4, F: 9.1, G: 12.4, H: 13.7, I: 14.3, J: 12.7, K: 11.6, L: 13.2, M: 11.7, N: 11.3, O: 13.4, P: 14.3, Q: 14.7, R: 13.0, S: 13.7, T: 16.4, U: 11.6, V: 13.9, W: 12.3, X: 13.5, Y: 16.8, Z: 12.8. From van den Bergh's paper "A Sequence of Photoelectric Standard Stars Surrounding NGC 6397" in the January 1, 1988, Astronomical Journal.

Sidney van den Bergh, Robert D. McClure, and Robert Evans, *Astrophysical Journal* **323**:44, December 1, 1987). The database for this study comprises Evans' 50,000 observations of one thousand bright galaxies amassed between 1980 and 1985. In this period he made eleven discoveries with a 10-inch Newtonian.

The senior authors looked at the discovery rate including discoveries by others in the same sample and separating them by class. Events of type Ia and Ib (the more luminous kind) occur only about one third as often as those of type II (like 1987A). Making corrections for distance, extinction by dust clouds in the host galaxies, the luminosity of the galaxies, and so on (lots of shaky assumptions and foo-foo dust are thrown about here!), some new numbers are found.

The bottom line is that for spirals as luminous as the Milky Way (pretty average), the rate is about one type I event per three hundred years and about one per hundred years for the fainter type II events. In other words, if you persistently monitor (like a few times each month) a couple of hundred galaxies, you will find a few supernovae each year — just what Rev Ev is finding.

Another paper by Sidney van den Bergh gives a good magnitude sequence around a bright southern globular cluster ("A Sequence of Photoelectric Standard Stars Surrounding NGC 6397," *AJ* **95**:106, January 1988). NGC 6397 is the closest globular, an honor sometimes shared with M4, which lies at a similar distance. The UBV observations are for stars well outside the crowded region of the cluster (a finder chart with the paper shows just where) and range from V magnitude 9.1 to 16.8.

The diameter of an open cluster has been measured accurately by a young Canadian astronomer ("Star Counts in the Open Cluster NGC 2420," Peter J. T. Leonard, *AJ* **95**:108, January 1988). The counts were made using a glass copy of the blue POSS field covering the area. The plate was digitally scanned on a PDS microdensitometer, which thus provided accurate positions and good-enough magnitudes for the stars. A region 1.4 square, encompassing 9,400 stars, was assayed.

Leonard's analysis suggests the cluster merges with the background at a diameter of 40 arcminutes, whereas visual observation would set the limit at only one quarter that size. The excess of stars compared to what is expected from the field alone is 685±27 stars to B magnitude 19.5 or so.

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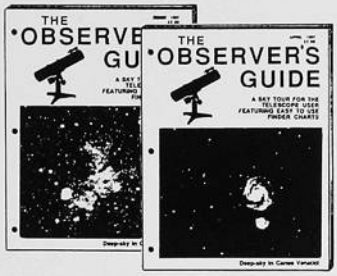

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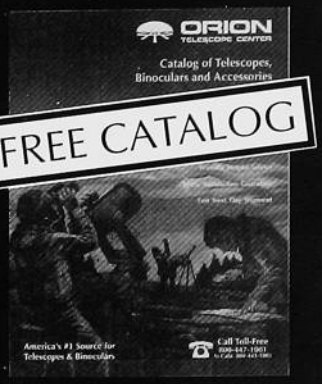

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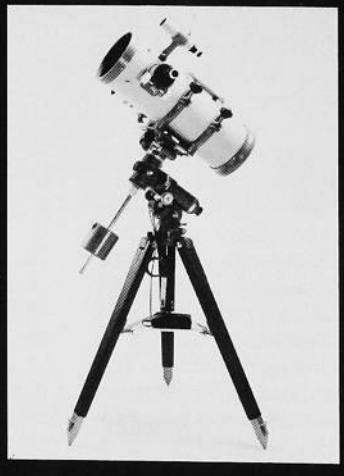

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DSM Reviews

Exploring the Southern Sky
Svend Laustsen, Claus Madsen, and Richard M. West
274 pp., cloth, $39.00
ISBN 3-540-17735-3
Springer-Verlag, New York (1987)

Subtitled "A Pictorial Atlas from the European Southern Observatory," this book is a magnificent collection of photographic images with extended captions that explain the pictures. The book contains 240 photographs (90 are in color), 31 diagrams, and a fold-out photographic panorama of the Milky Way. The photographic quality and reproduction are superb, and the images are printed on heavy, coated paper. Because it contains uniformly excellent photographs of a diverse range of objects, *Exploring the Southern Sky* is a valuable addition to the literature.

The book is presented in four sections. In the first chapter, "The Universe and Its Galaxies," we see stunning portraits of the Large Magellanic Cloud, NGC 1365, the Sombrero Galaxy, and NGC 6744. Included to supplement the "normal" photos are fresh color images of many galaxies made with CCD detectors, which often show remarkable detail near the galaxies' nuclei. Also included are a number of false-color intensity-contour photos of galaxies that show useful information about the surface brightnesses of the galaxies. And they're pretty too: the color schemes would have made Andy Warhol proud.

The second section focuses on the Milky Way Galaxy. Included is a black-and-white panorama of the Milky Way with familiar landmarks labeled, a dazzling negative view of the central region of M42, and many spectacular photographs of planetary nebulae, dark globules, and supernovae remnants. The third section, "Minor Bodies in the Solar System," opens with a shot of Comet Halley in Sagittarius. A remarkable section of plate shows multiple asteroid trails, and many images of comets are thrown in for good measure. The book's final chapter, "The Southern Sky and ESO," is a refreshing look at the European Southern Observatory and its role in modern astronomical research. The captions in this section explain a marvelous series of color photographs of the telescopes and buildings that make up ESO.

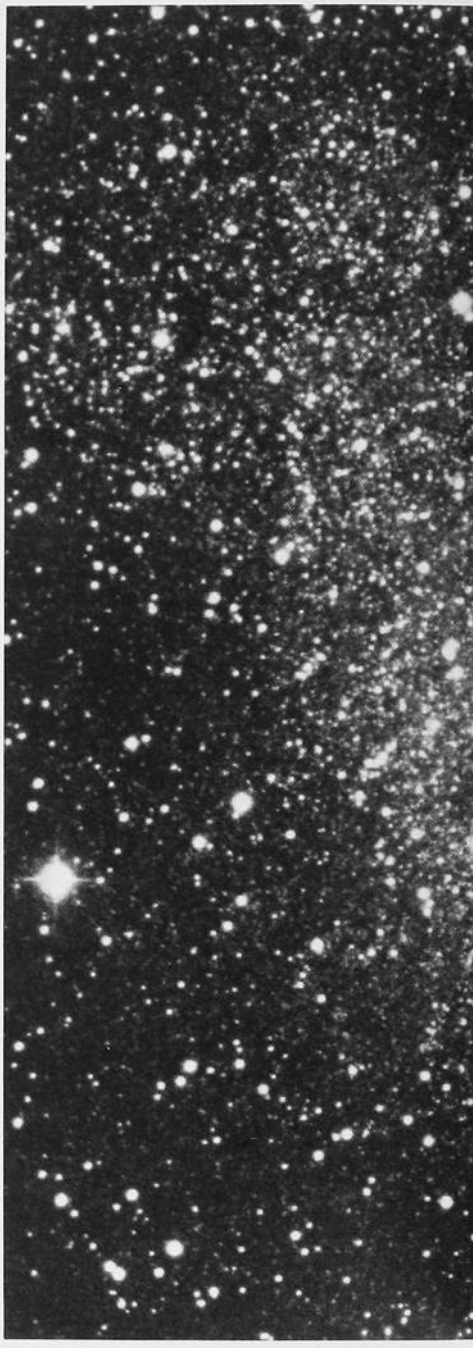
This is a landmark picture book of the sky. Many of the images are undoubtedly the best yet published, and the captions supplement the beautiful images without being heavy-handed. If you are interested in the southern sky or are a devotee of picture books containing deep-sky objects, this book is a must for your library shelf.

Supernova 1987A
Six slides and explanatory booklet, $10.50
ISBN 0-937707-15-5
Astronomical Society of the Pacific (1988)
[publisher's address: 1290 24th Avenue, San Francisco, CA 94122]

Splendors of the Universe
Fifteen slides and explanatory booklet, $18.95
Astronomical Society of the Pacific (1988)

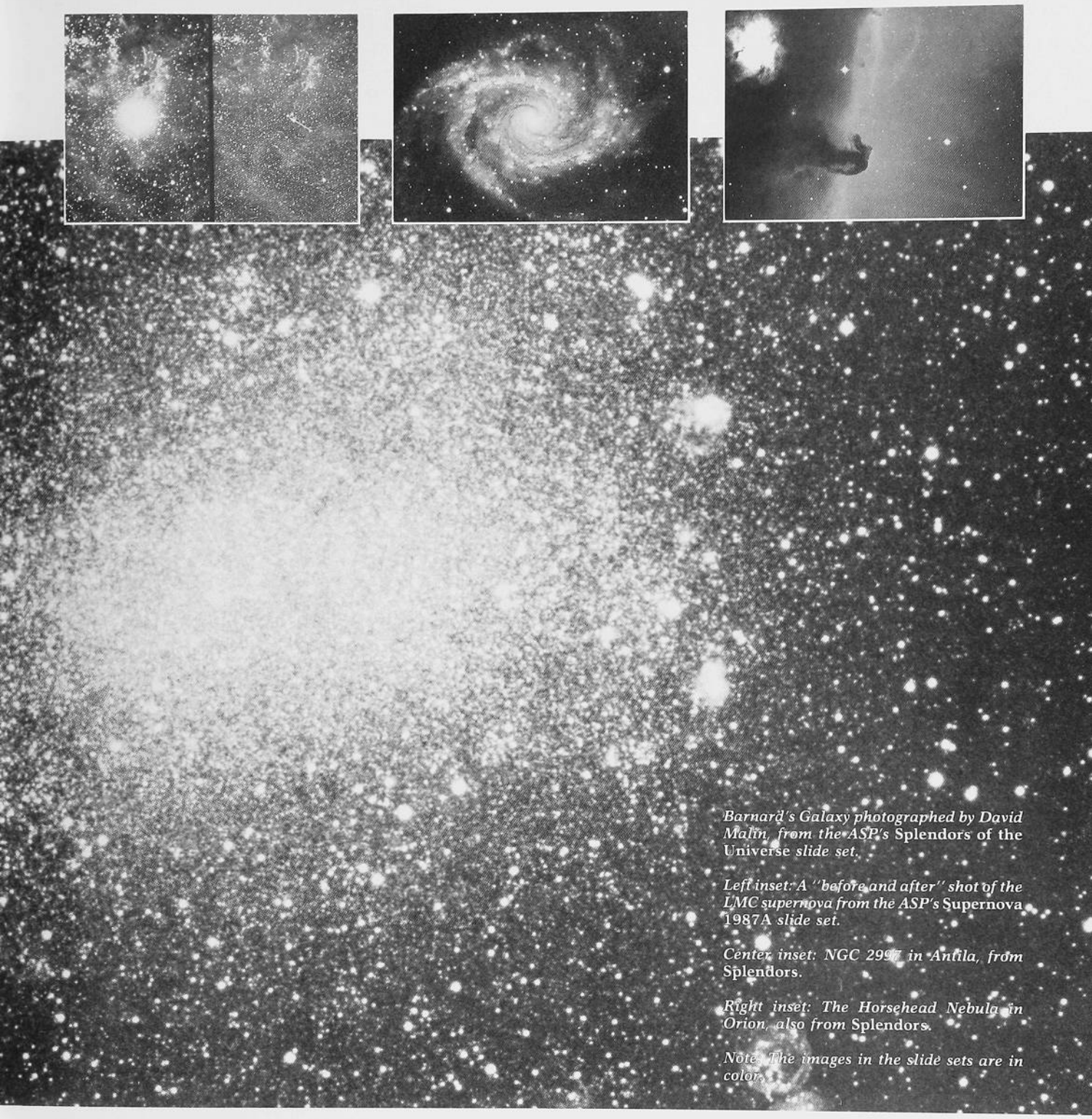
Two new slide sets from the Astronomical Society of the Pacific showcase deep-sky objects of different types. The first, a six-slide set, features some of the best images of the LMC supernova. The first image depicts the supernova along with the Tarantula Nebula three days after the supernova's discovery. The second shot is a "before and after" sequence in black and white, made by Ian Shelton, the discoverer. Slide three, a "before and after" color photo, pinpoints the progenitor star with an arrow. The final three slides are data related, showing the supernova's light curve through June 1987, its spectrum, and the IMB neutrino detection. A small booklet describing the event accompanies the slide set. This item makes a nice souvenir of the event, whether or not you were lucky enough to have seen the supernova firsthand.

Splendors of the Universe is a set of fifteen slides created by David Malin of the Anglo-Australian Observatory. This is a pretty-picture set, not claiming to offer a story but giving buyers magnificent colorful images of deep-sky objects. The images are first-rate; particularly impressive are the shots of Barnard's Galaxy in Sagittarius, the Horsehead Nebula, the Tarantula Nebula, and galaxy NGC 2997. In the set I received, some of the slides had a "faded" appearance as if they had been duplicated and reduplicated to the point where whites became tired-looking grays. But on the whole the set is very pleasing and will make a significant contribution to the image libraries of schools and astronomy clubs for use in talks and classes. In the past the ASP has published the very best available material in slide form, and it certainly has kept that standard in its two most recent sets.



Nearby Galaxies Atlas
R. Brent Tully and J. Richard Fisher
23 fold-out folio charts, spiral-bound, $59.50
ISBN 0-521-30136-X
Cambridge University Press (1987)

R. Brent Tully of the University of Hawaii and J. Richard Fisher of the National Radio Astronomy Observatory



Barnard's Galaxy photographed by David Malin, from the ASP's Splendors of the Universe *slide set.*

Left inset: A "before and after" shot of the LMC supernova from the ASP's Supernova 1987A *slide set.*

Center inset: NGC 2997 in Antila, from Splendors.

Right inset: The Horsehead Nebula in Orion, also from Splendors.

Note: The images in the slide sets are in color.

have produced a remarkable book. The *Nearby Galaxies Atlas* is the first volume to offer maps showing the two- and three-dimensional structure in groups of nearby galaxies.

In their introduction the authors state that the nearby universe is a "surprising sight, because there is so much organization." Indeed it is surprising, especially when viewed in three dimensions. The first eleven maps cover the entire celestial sphere in galactic coordinates and in two dimensions. Eleven colors on each map and a variety of shapes and sizes help show radial velocities of galaxies, types, and sizes.

It's a powerful way to see radial velocities of a great many galaxies at once. For example, on plate 11 you can see that the Virgo Cluster contains seven galaxies — M86, M90, M98, NGC 4318, NGC 4413, NGC 4419, and UGC 7470 — with radial velocities less than zero. Fifteen galaxies in the same field, however, have radial velocities between 2,000 and 3,000 kilometers per second.

Maps 12 through 23 show the sky in three dimensions by showing slices of various parts of nearby space. Plate 14 shows the Coma-Sculptor cloud and the Leo spur, including polar and edge-on views. Thus it is easy to see the large-scale distribution of nearby clouds of galaxies.

This product is invaluable for anyone interested in galaxies, whether it be on an observational or theoretical level. I heartily recommend it as a unique, important contribution to the field and a valuable addition to the libraries of serious deep-sky observers.

— *David J. Eicher*

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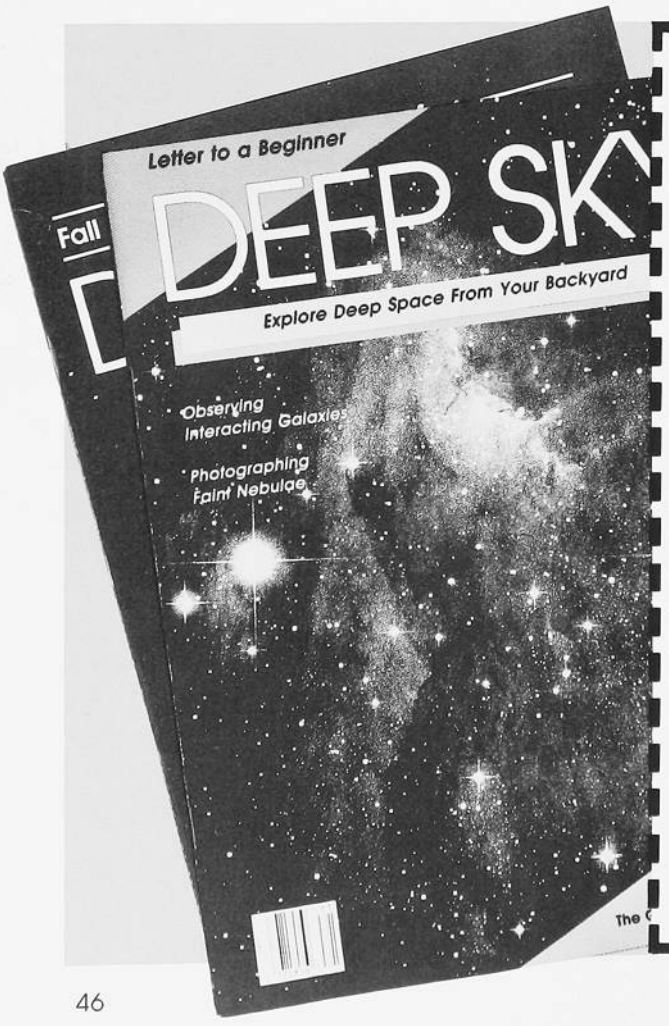

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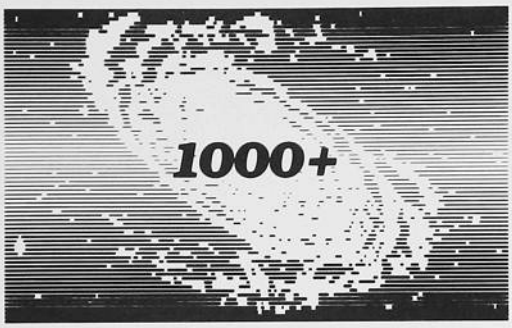

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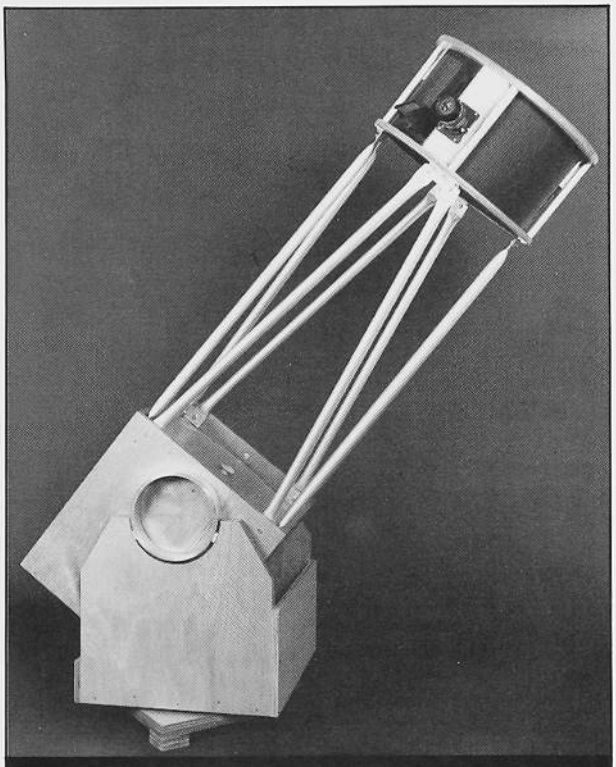

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